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Editorial Note

A New Era for the Journal of Medicine and Health Sciences

The Journal of Medicine and Health Sciences is a peer-reviewed academic journal published by the Faculty of Medicine, Srinakharinwirot University (SWU), Thailand. Since its establishment in 1994, the journal has served as an important platform for disseminating scholarly work across the fields of medicine and health sciences. Over the past three decades, the journal has remained committed to advancing scientific knowledge, encouraging interdisciplinary research, and supporting the translation of research evidence into clinical practice and public health.

The mission of the journal reflects the broader vision of Srinakharinwirot University as a “Learning University for Society,” which emphasizes the role of academic institutions not only in generating knowledge but also in contributing to social development and the well-being of communities. Complementing this institutional philosophy, the Faculty of Medicine, Srinakharinwirot University aspires to be “a medical institute with sustainable development for humanity.” This vision underscores the Faculty’s commitment to advancing medical education, research, and healthcare services in ways that promote long-term societal well-being and health system sustainability.

In alignment with these guiding principles, the Journal of Medicine and Health Sciences functions as an important scholarly platform for disseminating research that contributes to the advancement of medicine and health sciences while addressing real-world health challenges. The journal welcomes contributions from a broad range of disciplines, including clinical medicine, biomedical sciences, nursing, allied health sciences, public health, and medical and health sciences education. In addition, submissions that adopt cross-disciplinary approaches to issues related to medicine and the health sciences are encouraged.

As part of its ongoing development toward greater international engagement, the journal now publishes manuscripts in English to facilitate broader dissemination of knowledge and to strengthen communication within the global scientific community. Manuscripts are prepared according to internationally recognized formatting and referencing standards to ensure clarity, consistency, and transparency in scholarly communication.

All submitted manuscripts undergo a rigorous double-blind peer-review process conducted by three independent experts in relevant disciplines. The journal is also committed to maintaining the highest standards of research integrity and publication ethics. Authors are expected to adhere to internationally recognized ethical frameworks, including recommendations from the International Committee of Medical Journal Editors (ICMJE) and the Committee on Publication Ethics (COPE). These standards help ensure responsible authorship, transparency in research reporting, appropriate disclosure of conflicts of interest, and the reproducibility of scientific findings.

The contemporary landscape of medicine and health sciences is characterized by rapid scientific advancement alongside increasingly complex health challenges. Innovations in biomedical research, digital health technologies, and data-driven approaches are transforming disease prevention, diagnosis, and treatment. At the same time, global health concerns—including emerging infectious diseases, environmental health risks, population ageing, and the growing burden of noncommunicable diseases—highlight the need for collaborative and multidisciplinary approaches to research and practice.

Recognizing these developments, the journal particularly values research that integrates perspectives from multiple disciplines and addresses health challenges relevant to both regional and global contexts. Such complex health problems require collaborative approaches that bring together expertise from basic science, clinical science, epidemiology and public health, health technology, and social sciences.

As we move forward, the Journal of Medicine and Health Sciences remains committed to fostering the dissemination of high-quality research that advances evidence-based medicine and improves health outcomes. In line with the vision of Srinakharinwirot University and the Faculty of Medicine, the journal aims to contribute to scientific progress while serving society and promoting the well-being of communities in Thailand and beyond. Consistent with these goals, the current issue presents a diverse collection of studies spanning basic biomedical research, clinical research, allied health, public health, and health innovation.

Associate Professor Dr. Chatchai Ekpanyaskul, M.D., SFHEA
Editor-in-chief

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ORIGINAL ARTICLE

Comparative Outcomes of Endoscopic and Microscopic Tympanoplasty in Patients with Tympanic Membrane Perforation at HRH Princess Maha Chakri Sirindhorn Medical Center

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KEYWORDS

microscopic tympanoplasty; endoscopic tympanoplasty; graft take rate; complication; satisfaction

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ABSTRACT

Chronic otitis media with perforated eardrum is a common disease. Treatment involves tympanoplasty to heal the perforated eardrum. Traditionally, microscopic tympanoplasty (postauricular approach) has been used as the conventional method, but since the 1990s, endoscopic tympanoplasty (transcanal approach) have been used in tympanic membrane surgery. However, endoscopic-assisted surgery compels the doctor to use only one hand to perform the procedure since the other hand is used to hold the camera. Also, the operation area is small, and if bleeding occurs, it may easily obscure the surgical site. A total of 20 patients with tympanic membrane perforation were enrolled in this study and divided into two groups: endoscopic tympanoplasty using tragal perichondrium graft (n=10) and microscopic tympanoplasty using temporalis fascia graft (n=10). Graft success rates and patient satisfaction were evaluated. Clinical outcomes and complications were followed for at least 6 months postoperatively. Independent t-test, Mann-Whitney U test were used to analyze the outcomes and repeated measures analysis of variance was used to analyze pain score. The mean operation time and length of hospital stay were significantly longer in the microscopic tympanoplasty group (145 minutes, 70 hours) than the endoscopic tympanoplasty groups (90 minutes, 47 hours) ($p<0.001$). Graft success rates, clinical outcomes, and satisfaction scores were not significantly different between the two groups. No major complications were observed in either group.

Introduction

Chronic otitis media is a common disease, in which patients often show symptoms of tinnitus and ear discharge. Physical examination may reveal a perforated eardrum. Treatment involves myringoplasty to correct hearing impairment, heal the ruptured eardrum, and dry it¹. Microscopic-assisted surgery is the conventional method used for tympanic membrane surgery, as it allows the doctor to better visualize the ear's anatomy and physiology during the operation. This surgical method utilizes two surgical approaches: the postauricular approach and the transmeatal approach²⁻⁴. In 1967, Lade et al.⁵ introduced the use of the endoscope for diagnosis and imaging. Later, in the 1990s, the endoscope began to be used in tympanic membrane surgery. By opting for this surgical method, the doctor can bypass the postauricular approach, thereby reducing the risk of complications such as auricular deformity, while improving wound aesthetics, minimizing intraoperative bleeding, and reducing postoperative pain compared to the microscopic method. In addition, this surgery allows the doctor to see the entire tympanic membrane area and, notably, the entire ear anatomy clearly, including the round

window niche, Eustachian tube orifice, facial nerve, and incudostapedial joint. Also, additional canaloplasty is not required in patients with a narrow ear canal^{6,7}. However, endoscopic-assisted surgery compels the doctor to use only one hand to perform the procedure since the other hand is used to hold the camera. In addition, the operation area is small, and if bleeding occurs, it may easily obscure the surgical site. Recent studies⁸⁻¹⁰ have indicated that the operation time, length of hospital stay, and postoperative complications are higher in microscopic-assisted surgery compared to endoscopic-assisted surgery. Besides, patients undergoing endoscopic surgery are usually able to return to their normal daily life faster than those undergoing microscopic surgery. Post-surgery surveys of endoscopic patients have demonstrated a higher level of satisfaction with the aesthetic aspect of the incision than those of microscopic patients. While endoscopic-assisted surgery requires less operation time, the graft take rates for both methods are not significantly different. Although there are some reports from studies conducted in foreign countries comparing the effects of endoscopic tympanoplasty and microscopic tympanoplasty in patients with tympanic

membrane perforation, endoscopy is still considered a novel surgical method in Thailand. Additionally, alternative surgical techniques exist, and there is some uncertainty in current medical knowledge in Thailand regarding the success rates and differences in the quality of life of tympanic membrane perforation patients treated with endoscopic surgery versus microscopic surgery. Consequently, this research project aimed to compare the effects of endoscopic tympanoplasty with microscopic tympanoplasty in patients with tympanic membrane perforation, both in Thailand and around the world.

The objective of this study is to compare the graft take rates, clinical outcomes, complications, and patient satisfaction between endoscopic tympanoplasty and microscopic tympanoplasty.

Materials and Methods

This randomized controlled trial was conducted in patients aged 18 years old and older who were diagnosed with tympanic membrane perforation of any size by otolaryngologists at the outpatient unit of the Department of Otolaryngology, HRH Princess Maha Chakri Sirindhorn Medical Center, Faculty of Medicine, Srinakharinwirot University, Nakhon Nayok, Thailand. Patients with a history of mastoid infection, middle ear infection within 4 weeks before surgery, persistent otorrhea, cholesteatoma, or tympanic membrane surgery were excluded.

Sample size

The required sample sizes for the two independent study groups were determined based on discrete binary data using the following formula.

$$n2 = \frac{(z1 - \alpha + z1 - \beta)2}{(\epsilon - \delta)2} + \left[\frac{p1(1 - p1)}{k} + p2(1 - p2) \right]$$

$$\epsilon = p1 - p2$$

$$k = \frac{n1}{n2}$$

$$n1 = kn2$$

n1 = number of patients in the exposed group or experimental group

n2 = number of patients in the non-exposed group or control group

p1 = effect size in the exposed group or experimental group

p2 = effect size in the non-exposed group or control group

Z α / 2 = critical value corresponding to a 95% confidence level (α = 0.05)

Z β = critical value corresponding to 80% power (β = 0.20)

Nt (treatment) = 8

The sample size was calculated using the above formula to compare proportions between the two independent populations. The outcome was that each group should comprise at least 8 patients, which would provide sufficient power (80%) to indicate clinically significant differences at a 5% significance level. The researcher followed up with patients for up to 180 days post-surgery. In the study by Plodpai and Paje⁹, the graft take rates of patients undergoing endoscopic surgery and those undergoing microscopic surgery were 96.7% and 91.2%, respectively. However, a 20% sample withdrawal, absence from the trial, or non-compliance with the project protocols was anticipated, and therefore it was considered necessary to include a minimum of 10 patients per group, for a total of 20 patients, in this research project.

Simple randomized sampling into groups

The eligible patients were assigned into two groups, namely the endoscopic group and the microscopic group, using simple random sampling with random number table technique. However, follow-up and evaluation of the treatment plans for the initial 24 identified patients revealed that 4 patients were lost to follow-up. One of those patients had undergone endoscopic tympanoplasty, while 3 had undergone microscopic tympanoplasty. However, this still left 20 patients (10 patients from the endoscopic group and 10 patients from the microscopic group), which met the sample size criterion.

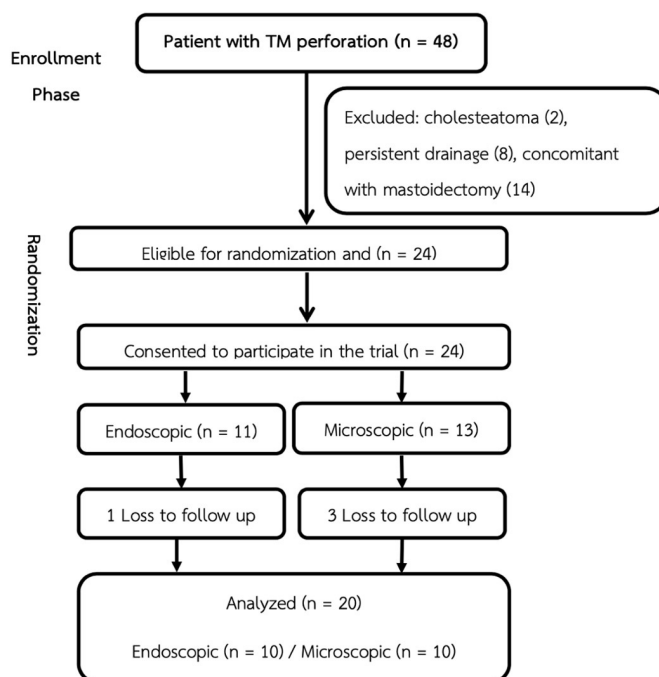


Figure 1 Participant flowchart

Surgical procedure

A Carl Zeiss microscope (Oberkochen, Germany) was employed for microscopic tympanoplasty by the postauricular approach. A temporalis fascia graft was applied for tympanic membrane repair. Also, 1% xylocaine with 1:100,000 epinephrine was administered into the external ear canal and the postauricular incision.

In endoscopic tympanoplasty, a high-definition monitor and camera (Karl Storz, Germany) were used, and videos were recorded on a computer hard disc. A Xenon light source (Karl Storz Xenon Nova 175, Tuttlingen, Germany) and 3 mm (18 cm length) Hopkins rod lens rigid 0°, 30° endoscope (Karl Storz Endoscopes, Tuttlingen, Germany) were utilized. Additionally, 1% xylocaine with 1:100,000 epinephrine was injected into the external ear canal, and a tragal perichondrium graft was used to repair the tympanic membrane. Tragal cartilage was harvested by making a 1 cm incision along the tragus.

Both tragal cartilage perichondrium and temporal muscle fascia are all eligible for result in safe and successful surgery¹¹ and all cases in this study were operated on by the same senior surgeon.

Data collection

The researcher conducted a preliminary physical examination and gathered the patient history and general information (gender, age, vital signs, underlying diseases, and drug allergy history). Data on current symptoms, such as length of time before admission, ear itching, earache, ear discharge, and hearing level, were also collected. A questionnaire was used to assess satisfaction at the end of

the study (180 days). The visual analogue scale was applied for postoperative pain evaluation at 1 hour, 3 hours, and 1 day after the surgery. The researcher reviewed the patients' medical records to assess the length of stay and operation time, as well as to follow up and evaluate postoperative complications at 30, 90, and 180 days.

Data analysis

Descriptive statistics were used for data analysis. Frequency, percentage, mean, standard deviation, median, and range (minimum and maximum) were calculated. Graft take rates were compared using Fisher's exact test. Comparative analyses of clinical outcomes, complications, and patient satisfaction between the two groups of patients undergoing endoscopic tympanoplasty and microscopic tympanoplasty were conducted using independent t-test, Mann-Whitney U test, and repeated measures analysis of variance. Data from all patients were analyzed using the above-mentioned statistical methods through the data analysis program STATA version 13.0 (College Station, TX). The statistical significance was set at 5% ($p < 0.05$).

Results

The 10 patients undergoing endoscopic tympanoplasty comprised 7 females (70%) and 3 males (30%), while the 10 patients undergoing microscopic tympanoplasty comprised 7 males (70%) and 3 females (30%). Despite the gender distribution differences, the two groups of patients were similar; most of them underwent left tympanoplasty at the anterior position with a small perforation size (Table 1).

Table 1 Demographic data of the participants (endoscopic and microscopic group)

Demographic Categories	Endoscopic (n = 10)		Microscopic (n = 10)		Total (n = 20)		p-value*
	n	%	n	%	n	%	
Sex							0.089
Male	3	30	7	70	10	50	
Female	7	70	3	30	10	50	
Affected ear							0.175
Left	8	80	5	50	13	65	
Right	2	20	5	50	7	35	
Perforation size							0.291
Small	9	90	7	70	16	80	
Medium	1	10	3	30	4	20	
Large	0	0	0	0	0	0	
Perforation site							0.175
Anterior	5	50	8	80	13	65	
Posterior	5	50	2	20	7	35	

The size of perforation: small perforation, <1 quadrants, middle perforation, >1 quadrants and <2 quadrants; and large perforation, >2 quadrants

*Statistical analysis with Fisher's exact test

A comparative study of the clinical outcomes between patients undergoing endoscopic tympanoplasty and microscopic tympanoplasty revealed that post-surgery follow-up of graft take rates at all time intervals (30 days, 90 days, and 180 days) showed differences between the two groups, but without statistical significance (Table 2). In addition, no patients in either group required canaloplasty, and intraoperative blood loss was less than 30 ml. Although

pain scores at 1 hour, 3 hours and 24 hours after the operation differed between the two groups, the differences were not statistically significant (Table 3). However, comparison of the pain scores for each time period showed that the 24-hour postoperative pain scores were significantly lower than both the 3-hour postoperative pain scores ($p < 0.001$) and the immediate postoperative pain scores ($p < 0.001$).

Table 2 Graft success rate (endoscopic and microscopic group)

Timing (days)	Endoscopic (n = 10)		Microscopic (n = 10)		p-value*
	Failure	Uptake	Failure	Uptake	
7	0	10	0	10	-
30	0	10	1	9	0.500
90	1	9	3	7	0.291
180	1	9	2	8	0.500

*Statistical analysis with Fisher's exact test

Table 3 Pain scores (endoscopic and microscopic group)

Pain scores	Endoscopic (n = 10)	Microscopic (n = 10)	Total (n = 20)	p-value
Timing (hours)				
1	3.5±1.4	4.2±0.8	3.9±1.1	0.175*
3	3.5±1.4	4.1±0.8	3.8±1.1	0.234*
24	2.3±1.4	2.3±0.5	2.3±1.0	1.000*

3h vs. 1h = -0.05, 95%CI -0.39-0.29, p -value = 0.770*; 24h vs. 1h = -1.55, 95%CI -1.21- -1.89, p -value < 0.001**; 24h vs. 3h = -1/50, 95%CI -1.16- -1.84, p -value < 0.001**

*Statistical analysis with Independent test, **Statistical analysis with Repeated Measures Analysis of Variance

The difference in the preoperative and postoperative air-bone gap (Δ ABG) varied between the two patient groups: 15.0 ± 7.9 dB in the group undergoing endoscopic tympanoplasty and 17.8 ± 5.5 dB in the group undergoing microscopic tympanoplasty. However, the difference was not statistically significant ($p=0.366$) (Table 4). Patients undergoing endoscopic tympanoplasty, however, required a shorter operation time and length of stay—90 minutes (range: 50-105) and 47 hours (range: 45-70), respectively—than those undergoing microscopic tympanoplasty, who

required 145 minutes (range: 90-160) and 70 hours (range: 58-72), with statistical significance (Table 4). Neither group experienced major complications requiring intraoperative or postoperative surveillance, such as postauricular numbness, ear bruising, or surgical wound infection. Postoperative satisfaction scores suggested that the endoscopic and microscopic groups differed in overall satisfaction, but the difference was not statistically significant (7.5 vs. 7.0, $p=0.189$).

Table 4 Clinical outcomes, complications, and patient satisfaction (endoscopic and microscopic group)

Categories	Endoscopic (n = 10)	Microscopic (n = 10)	Total (n = 20)	p-value
No required canaloplasty	10	10	20	-
Minimal blood loss < 30 ml	10	10	20	-
Operating times (mins)	90 (50-105)	145 (95-160)	100 (50-160)	<0.001*
Length of stay (hrs)	47 (45-70)	70 (58-72)	59 (45-72)	<0.001*
Air-bone gap (dB)				
Pre-operative	19.2 $\pm$ 10.8	22.1 $\pm$ 8.3	20.2 $\pm$ 9.4	0.664*
Post-operative	4.2 $\pm$ 6.1	3.3 $\pm$ 6.3	3.8 $\pm$ 6.1	0.689*
Δ ABG	15.0 $\pm$ 7.9	17.8 $\pm$ 5.5	16.4 $\pm$ 6.7	0.366*
No complications	10	10	20	-
Patient satisfaction (180 days)	7.5 (5.0-8.0)	7.0 (5.0-8.0)	7.0 (5.0-8.0)	0.189*

*Statistical analysis with Mann-Whitney test, **Statistical analysis with Independent test

Discussion

A comparative study on the effects of endoscopic tympanoplasty and microscopic tympanoplasty in patients with tympanic membrane perforation suggested that the graft take rates at all time intervals (30 days, 90 days, and 180 days) differed between the two groups but without statistical significance. This finding is consistent with a previous study by Plodpai and Paje⁹, who reported that the graft take rates for endoscopic-assisted surgery patients were higher than those for microscopic-assisted surgery patients. The present study also concurs with previous international research that indicated no significant differences between postoperative graft take rates for both methods^{9,12}. In addition, the current study indicated that differences in preoperative and postoperative hearing levels, intraoperative blood loss, and pain scores on the first day after surgery between the two groups were not statistically significant, which was consistent with earlier studies. Both groups of patients showed no significant differences in preoperative and postoperative hearing levels, pain scores, intraoperative blood loss, and pain levels on the first day after surgery^{9,13}. However, both methods of surgery produced only small differences in wound size, which may explain the similar intraoperative blood loss and pain scores recorded 1 day after the surgery.

Patients undergoing endoscopic tympanoplasty required less operation time and had a shorter length of stay than those undergoing microscopic tympanoplasty, with statistical significance. This finding is consistent with recent studies reporting that endoscopic-assisted surgery takes less operating time than microscopic-assisted surgery⁹, due to

the limited visualization of the perforation with the microscope, which requires more time spent examining the entire tympanic membrane¹⁴. Patients undergoing microscopic tympanoplasty had a longer hospital stay than those undergoing endoscopic tympanoplasty, which is consistent with the study conducted by Nassif et al.⁸. It was also found that patients undergoing microscopic-assisted surgery spent more time in the hospital due to the incision being at the back of the ear pinna, which may require pressure to be applied to the wound for at least 24 hours after the surgery in order to stop any bleeding. As a result, this group required a longer hospital stay than the group undergoing endoscopic surgery, which involved only a 1–2 cm surgical incision.

In addition, the current study showed that no serious postoperative complications were reported in either group, i.e., no major issues requiring close observation, such as numbness at the back of the ear, ear bruising, or an infected surgical wound. Postoperative assessment of satisfaction levels in the two groups suggested that patients in both the endoscopic-assisted and microscopic-assisted surgery groups gave similar scores (7.5 [range 0–8] vs. 7.0 [range 0–8] points). This was surprising, since some endoscopic surgery patients were treated with a tragal perichondrium graft, which could result in a visible scar. This finding was also inconsistent with studies by Harugop et al.¹⁵ and Kim et al.¹⁶, who found that patients undergoing endoscopic-assisted surgery reported higher satisfaction with the aesthetic outcome than those undergoing microscopic-assisted surgery, as the latter group often had scars above the hairline.

This study has certain limitations. The sample size was relatively small, which may have limited the statistical power to detect subtle differences between two groups and the study was conducted in a single tertiary center, which may affect the generalizability of the finding to other settings or patient populations. Further multicenter studies with large sample sizes are recommend to validate and extend these results.

Conclusions

The findings from this comparative study on the effectiveness of endoscopic and microscopic surgeries in patients with tympanic membrane perforation indicate that operation time and length of stay were shorter for patients undergoing endoscopic surgery than for those undergoing microscopic surgery. However, the graft take rates, postoperative hearing levels, and intraoperative blood loss showed no significant differences. In addition, there were no reports of serious adverse postoperative events in either surgical group, and no significant differences in patient satisfaction between the two groups. The study results allow us to conclude that the endoscopic method of myringoplasty is not less effective in treating patients with tympanic membrane perforation than the microscopic method. Therefore, endoscopic surgery may serve as an alternative treatment option for patients with a perforated tympanic membrane.

Ethical Approval

This study was approved by the Institutional Human Research Ethics Committee of Srinakharinwirot University (protocol code SWUEC-080/61E; approval date: 1 June 2018). Informed consent was obtained from all participants or their legal representatives.

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บทความวิจัย

การเปรียบเทียบผลของการผ่าตัดซ่อมแซมเยื่อแก้วหูด้วยวิธีเอนโดสโคปและวิธีจุลศัลยกรรมในผู้ป่วยที่มีภาวะเยื่อแก้วหูทะลุในศูนย์การแพทย์สมเด็จพระเทพรัตนราชสุดาฯ สยามบรมราชกุมารี

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คำสำคัญ

การผ่าตัดแก้ไขเยื่อแก้วหูโดยใช้กล้องจุลทรรศน์; การผ่าตัดแก้ไขเยื่อแก้วหูโดยใช้กล้องเอนโดสโคป; อัตราการติดของเยื่อแก้วหู; ภาวะแทรกซ้อน; ความพึงพอใจ

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บทคัดย่อ

โรคหูชั้นกลางอักเสบเรื้อรังร่วมกับเยื่อแก้วหูทะลุเป็นโรคที่พบได้บ่อย การรักษาประกอบด้วย การผ่าตัดปะเยื่อแก้วหู (tympanoplasty) เพื่อซ่อมแซมเยื่อแก้วหูที่ทะลุและลด การติดเชื้อซ้ำซ้อน ในอดีตนิยมใช้กล้องจุลทรรศน์ (microscope) เป็นวิธีมาตรฐาน ในการผ่าตัด อย่างไรก็ตาม ในปัจจุบันได้มีการนำกล้องเอนโดสโคป (endoscope) มาใช้ในการผ่าตัดบริเวณเยื่อแก้วหู การผ่าตัดโดยใช้กล้องเอนโดสโคปนั้นแพทย์จำเป็นต้องใช้มือเพียงข้างเดียวในการผ่าตัด เนื่องจากอีกข้างหนึ่งต้องถือกล้องเอนโดสโคป ไว้ตลอดเวลา นอกจากนี้ บริเวณที่ทำการผ่าตัดมีขนาดเล็ก หากมีเลือดออก ระหว่างผ่าตัดอาจบดบังพื้นที่การผ่าตัดได้ง่าย การศึกษานี้เป็นการศึกษาแบบ randomized controlled trial ศึกษาในผู้ป่วยเยื่อแก้วหูทะลุ จำนวน 20 ราย แบ่งเป็น 2 กลุ่ม คือ กลุ่มที่ได้รับการผ่าตัดปะแก้วหูแบบใช้กล้อง Microscope 10 ราย และกลุ่ม ที่ใช้กล้อง Endoscope 10 ราย ประเมินความสำเร็จของกราฟ ติดตามผลลัพธ์ทางคลินิก และภาวะแทรกซ้อนระหว่างการผ่าตัดปะแก้วหูแบบใช้กล้อง Endoscopic เทียบกับ การผ่าตัดแบบใช้กล้อง Microscopic เป็นระยะเวลา 6 เดือน วิเคราะห์ข้อมูลโดยใช้สถิติ Independent t-test, Mann-Whitney U test และ repeated measures analysis of variance จากผลการศึกษาพบว่าระยะเวลาการผ่าตัดและระยะเวลารักษาตัวใน โรงพยาบาลเฉลี่ยหลังการผ่าตัดแบบ Microscopic (145 นาที, 70 ชั่วโมง) มากกว่า กลุ่มที่ได้รับการผ่าตัดแบบ Endoscopic (90 นาที, 47 ชั่วโมง) อย่างมีนัยสำคัญ ทางสถิติ ($p < 0.001$) ส่วนอัตราความสำเร็จของกราฟ ผลลัพธ์ทางคลินิก และคะแนน ความพึงพอใจของผู้ป่วยทั้งสองวิธีแตกต่างกันอย่างไม่มีนัยสำคัญทางสถิติ และไม่มี ภาวะแทรกซ้อนที่สำคัญในผู้ป่วยทั้งสองกลุ่ม โดยสรุป การผ่าตัดปะเยื่อแก้วหูแบบใช้กล้อง Endoscopic มีอัตราความสำเร็จของกราฟและผลลัพธ์ทางคลินิกไม่ด้อยกว่าการผ่าตัด รักษาแบบใช้กล้อง Microscopic ในกลุ่มผู้ป่วยเยื่อแก้วหูทะลุ

ORIGINAL ARTICLE

Effectiveness of a Developed Workshop Compared with Interactive Lectures on Psychiatric Interviewing among Medical Students at the School of Medicine, Mae Fah Luang University

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KEYWORDS

workshop; interactive lectures; psychiatric interviewing; effectiveness

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ABSTRACT

Psychiatric interviewing is a crucial component in the care of patients with mental health conditions, requiring both theoretical knowledge and practical skills. This necessity underpins the ongoing efforts to explore and develop the most effective teaching methods to enhance medical students' competencies in this area. The present study was driven by the objective to compare the effectiveness of a developed workshop-based instructional model and the conventional interactive lecture format in teaching psychiatric interviewing. This research employed a retrospective observational design, utilizing data from a total of 264 fourth-year medical students at Mae Fah Luang University. Assessment tools included a post-instruction satisfaction questionnaire and a structured evaluation of students' knowledge and skills in psychiatric history-taking. Data were collected from two student groups: those who participated in interactive lectures between 2016 and 2019, and those who received workshop-based instruction between 2020 and 2024. Data analysis was performed using independent t-tests. The findings revealed that students in the workshop group scored significantly higher than those in the interactive lecture group in terms of rapport-building skills and active listening ($p < 0.001$). However, the demonstrating empathy toward patients remained relatively low in both groups. In contrast, students in the interactive lecture group demonstrated significantly better theoretical knowledge ($p < 0.001$). In conclusion, the workshop model proved more effective in developing practical skills, while the interactive lecture format was superior for enhancing theoretical understanding. These results suggest that an integrated approach, combining workshop-based learning with interactive lectures, may more effectively equip medical students with both the skills and knowledge required for competent psychiatric interviewing. Nevertheless, further attention is needed to improve students' abilities in empathic understanding. This study provides valuable insights for the future development of psychiatric education curricula.

Introduction

In contemporary medical education, there is a growing emphasis on student-centered learning, reflecting the global shift toward more active, engaging, and personalized instructional models. Despite this paradigm shift, an ongoing debate persists regarding the most effective teaching methodologies for clinical training, particularly in complex and nuanced areas such as psychiatry¹. With a variety of instructional formats available, ranging from traditional lectures and workshops to case-based discussions and self-directed learning, educators continue to explore how best to meet diverse learner needs. No single pedagogical method has demonstrated unequivocal superiority across all contexts. Thus, effective curriculum design must remain flexible and responsive, integrating learners' characteristics, student feedback, and faculty expertise to optimize educational outcomes². Lectures, long considered

the cornerstone of medical education, retain a critical role in delivering comprehensive foundational knowledge. Their effectiveness, however, is greatly enhanced when interactivity is embedded into their structure. Interactive lectures that promote dialogue, questions, and critical analysis have been shown to stimulate higher-order thinking and maintain learner engagement³. This format fosters a dynamic classroom environment in which students not only absorb information but also learn to apply and interrogate it. In contrast, workshops represent a fundamentally different approach, emphasizing experiential, hands-on learning. By engaging learners in simulations, role-play, collaborative activities, and immediate feedback, workshops actively develop essential clinical competencies. This form of instruction is particularly well-suited to skills-based learning, where knowledge alone is insufficient without the ability to apply it in practice.

The teaching of psychiatric interview skills offers a compelling case study in the need for multifaceted educational strategies. As a central component of fourth-year medical training, psychiatric interviewing goes beyond conventional history-taking. It demands a unique integration of medical knowledge with advanced communication skills, emotional intelligence, and the ability to establish therapeutic rapport. The ability to listen actively, empathize sincerely, and interpret both verbal and nonverbal cues is paramount. Mastery of these competencies directly influences diagnostic accuracy, treatment planning, and the overall quality of patient care⁴. Interactive lectures in psychiatric interviewing can be particularly effective in promoting conceptual understanding and analytical thinking. They enable students to explore theoretical models of mental health, diagnostic criteria, and clinical decision-making. However, the inherently human and interpersonal nature of psychiatric care also requires immersive training environments where learners can practice and reflect on their communication behaviors. Workshops fill this gap by simulating real-world clinical encounters, allowing students to role-play as both clinician and patient. These settings provide invaluable opportunities for peer feedback, faculty guidance, and personal reflection, each of which contributes to the development of confidence, empathy, and professionalism. Several studies have highlighted the value of workshop-based instruction in enhancing psychiatric interviewing skills. Participants typically report higher confidence, improved interpersonal communication, and greater readiness to manage psychiatric patients in clinical settings⁵. Despite these promising outcomes, direct comparisons between interactive lectures and workshops in psychiatric education remain limited in number and scope. More empirical evidence is needed to determine the optimal balance between theoretical instruction and experiential learning in this domain.

At Charoenkrung Pracharak Hospital, a core clinical training site for Mae Fah Luang University since 2016, psychiatric interviewing has become a focal point of fourth-year medical education. The hospital's training program recognizes the pedagogical challenges of teaching such a complex and sensitive skill and aims to equip students with both the knowledge and personal qualities essential for compassionate, evidence-based care. Given the increasing demands placed on future physicians to engage with patients not just diagnostically but holistically, the selection of the most appropriate and effective teaching strategy is not just educationally significant, but it is ethically imperative. Psychiatric interviewing has been an integral part of the fourth-year medical curriculum since the inception of the psychiatry rotation at Charoenkrung Pracharak Hospital in 2016. Internal evaluations over the past nine academic years have indicated that while students generally achieve satisfactory scores in theoretical assessments, performance in practical components, particularly rapport building, active listening, and empathic engagement, has been inconsistent. Annual satisfaction surveys have further revealed that students often express a desire for more hands-on practice and real-time feedback during their psychiatric training. Department observations echo these findings, noting that although interactive lectures effectively deliver conceptual frameworks, they may not provide sufficient opportunities for students to internalize and apply these skills in clinical simulations. These institutional trends underscored the

need for a systematic evaluation of teaching strategies to identify the most effective approach for balancing theoretical knowledge with practical skill development in psychiatric interviewing. The objective of this study was to compare the effectiveness of two teaching methods interactive lectures and developed workshops in psychiatric interviewing by evaluating fourth-year medical students' knowledge, skills, overall satisfaction, perceived learning effectiveness, and the ability to apply these skills.

Materials and Methods

This research was conducted as a retrospective observational study comparing two naturally occurring cohorts (interactive lecture vs. workshop) within a routine-to-research (R2R) context. The study population consisted of 264 fourth-year medical students who had completed the psychiatry course at Mae Fah Luang University between the academic years 2016 and 2024. All fourth-year medical students completing the psychiatry course during the study period were included. No random sampling was performed. Exclusion criteria included students who had deferred their studies, withdrawn, or were no longer enrolled prior to taking the psychiatry course.

The sample size for this study was estimated using the formula for comparing two independent means:

$$n = \frac{2(Z_{1-\alpha/2} + Z_{1-\beta})^2 \sigma^2}{\Delta^2}$$

where $Z_{1-\alpha/2} = 1.96$ for a 95% confidence level, $Z_{1-\beta} = 0.84$ for 80% statistical power, σ is the standard deviation, and Δ is the minimum detectable difference between groups.

Assuming a standard deviation (σ) of 10 and a desired minimum difference (Δ) of 5 points in outcome measures, the calculated sample size per group is approximately 63 participants, totaling 126 for both groups combined. In comparison, the actual sample size used in this study included 264 fourth-year medical students who completed the psychiatry course between 2016 and 2024, which exceeds the calculated sample size. This larger sample size enhances the study's statistical power and robustness.

Data collection involved gathering knowledge assessment scores, student satisfaction surveys, and clinical performance ratings from actual patient interviews. The instruments, developed by the institution in collaboration with experts in medical education and psychiatry, included the following components. The student-rated measure was a satisfaction questionnaire utilizing a five-point Likert scale assessing content relevance, delivery quality, learner engagement, and perceived skill improvement. The validation process involved a separate cohort of 64 fourth-year medical students (aged 22.15 ± 1.05 years), who completed the assessments at two time points spaced two weeks apart to evaluate test-retest reliability. This instrument demonstrated a content validity index (CVI) of 0.82 and a test-retest reliability coefficient of 0.85. The questionnaire was administered once to all students at the end of the learning session.

An educator provided ratings for students (1) overall knowledge level and (2) participation in discussion, on a five-point scale (5 = Excellent, 4 = Good, 3 = Moderate, 2 = Fair, 1 = Poor). This assessment was conducted by the same educator across all academic years and validated using the same cohort of 64 students for test-retest reliability. It yielded

a CVI of 0.85 and a test–retest reliability coefficient of 0.89. The assessment was administered once individually to each student at the end of the learning session.

Another educator-rated measure involved psychiatric clinical performance ratings, which consisted of structured evaluations derived from actual patient interviews, scored on a ten-point scale with clearly defined criteria and categorized into four domains: Overall Interviewing Skill, Rapport Building, Active Listening, and Empathy. Each student's performance was independently rated by five psychiatrists, who had undergone regular inter-rater reliability training. Inter-rater reliability was calculated from these independent ratings, resulting in a coefficient of 0.90. Content validity was assessed by 10 experts, who provided a CVI of 0.89 for this instrument. Each student was evaluated once on an individual basis immediately after completing the real patient interview.

The data were collected from two sequential cohorts. The first cohort consisted of 126 students who completed their psychiatry rotation between 2016 and 2019 and underwent interactive lectures. The second cohort included 138 students who completed their psychiatry rotation between 2020 and 2024 and participated in workshop-based learning. This workshop began with a brief review of the primary topics on psychiatric history-taking that students had previously studied. A psychiatrist then conducted a simulated patient interview, allowing students to practice active listening by focusing on the patient's verbal communication and emotional expressions. This was followed by a group discussion to enhance comprehension. Subsequently, students practiced their speaking skills by articulating observations and reflections before the class. They alternated

roles between interviewer and standardized patient using scenarios derived from actual clinical situations, which enabled them to engage from both perspectives. Finally, each student composed a clinical documentation report based on the mental history they collected. Throughout the workshop, a continuous process of reflection and feedback was implemented under the meticulous observation and guidance of a faculty psychiatrist.

Instructional conditions were standardized across cohorts, with identical course content delivered by the same educator according to a standardized lesson plan. Workshop standardized patients were trained by the educator, with refresher training annually, and where possible, the same standardized patients were used across years. Post-course knowledge assessments were conducted by the same educator each year, and inter-rater reliability for patient history-taking evaluations was verified annually. Data on certain student characteristics (e.g., prior academic performance, mental health, prior exposure to psychiatry) were not collected due to methodological constraints and feasibility considerations.

Descriptive statistics such as means, standard deviations, frequencies, and percentages were used to summarize continuous and categorical outcome measures. To assess the comparative effectiveness of interactive lectures versus workshop-based learning, inferential statistical tests were applied to outcome measures of interest. Continuous outcomes, such as student satisfaction rating scores, knowledge test scores, and skills assessment ratings, were compared between groups using independent t-tests. The entire research process described above is summarized in a flowchart, as illustrated in Figure 1.

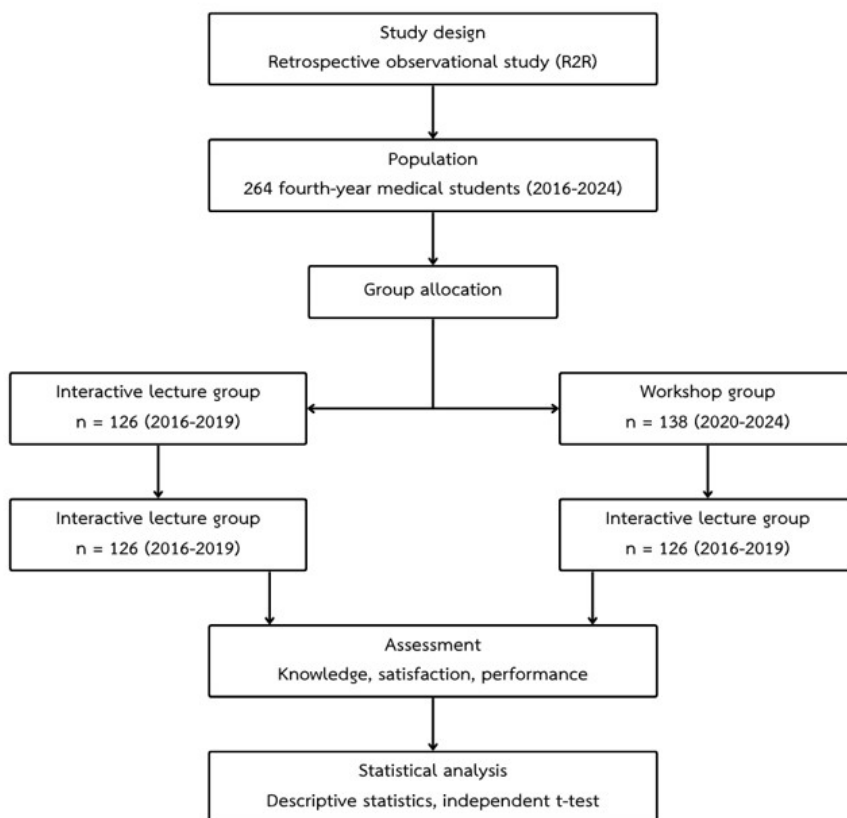


Figure 1 Flow chart of research process

Results

A total of 264 fourth-year medical students were included in the analysis, comprising 138 students in the workshop group and 126 students in the interactive lecture group. The mean age of participants was comparable between groups (22.34 ± 2.69 years vs. 22.05 ± 2.21 years). In terms of sex distribution, the workshop group consisted of 34 males (24.64%) and 104 females (75.36%), while the interactive lecture group included 41 males (32.54%) and 85 females (67.46%). Regarding regional background, approximately half of the students in both groups originated

from the Northern region (50.72% in the workshop group vs. 46.83% in the interactive lecture group), with the remainder from other regions. Academic performance during preclinical years, as measured by GPAX, showed a similar distribution between groups. In the workshop group, 97 students (70.29%) achieved a $GPAX \geq 3.00$, compared with 90 students (71.43%) in the interactive lecture group. The majority of students in both groups reported being Buddhist (96.38% in the workshop group vs. 95.24% in the interactive lecture group), with only a small proportion identifying with other religions, as shown in Table 1.

Table 1 Baseline characteristics between workshop and interactive lecture groups

Characteristic	Workshop n=138 (%)	Interactive lecture n=126 (%)
Sex		
Male	34 (24.64%)	41 (32.54%)
Female	104 (75.36%)	85 (67.46%)
Age		
Mean $\pm$ SD	22.34 $\pm$ 2.69	22.05 $\pm$ 2.21
Region of origin		
Northern region	70 (50.72%)	59 (46.83%)
Other regions	68 (49.28%)	67 (51.17%)
Preclinical GPAX		
≥ 3.00	97 (70.29%)	90 (71.43%)
< 3.00	41 (29.71%)	36 (28.57%)
Religion		
Buddhist	133 (96.38%)	120 (95.24%)
Others	5 (3.62%)	6 (4.76%)

From Table 2, the student evaluation results show that students in the workshop group reported significantly higher overall satisfaction compared with those in the interactive lecture group (94.62 $\pm$ 2.82 vs. 86.82 $\pm$ 2.31; mean difference=7.80; $t=24.67$; $p<0.001$). Similarly, perceived learning effectiveness was slightly but significantly higher among workshop participants (93.46 $\pm$ 4.28 vs. 92.23 $\pm$ 3.52; mean difference=1.23; $t=2.56$; $p=0.011$). Application of knowledge showed a marked improvement in the workshop group (90.82 $\pm$ 3.43 vs. 82.34 $\pm$ 2.65; mean difference=8.48; $t=22.58$; $p<0.001$). Confidence in interviewing patients was also significantly greater in the workshop cohort compared with the lecture group (87.21 $\pm$ 4.02 vs. 79.45 $\pm$ 3.81; mean difference=7.76; $t=16.10$; $p<0.001$). These findings indicate that workshop-based instruction yielded higher levels of satisfaction, perceived learning, and practical application compared with lecture-based instruction, as shown in Figure 2.

Educator-rated outcomes regarding knowledge at the end of the learning session also revealed significant differences between the two groups. Students in the workshop group demonstrated lower post-training knowledge scores compared with those in the interactive lecture group (74.50 $\pm$ 3.57 vs. 79.00 $\pm$ 3.53; mean difference=-4.50; $t=-10.29$;

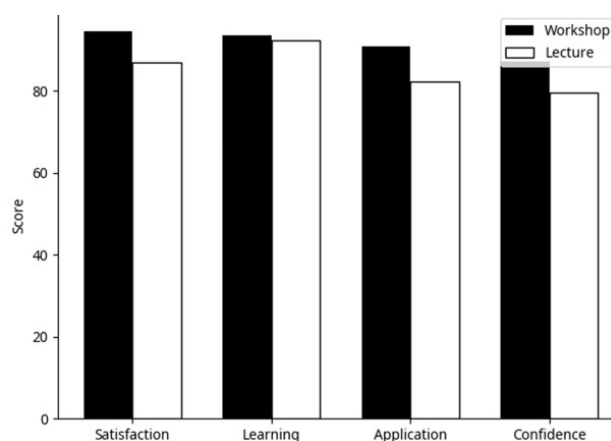
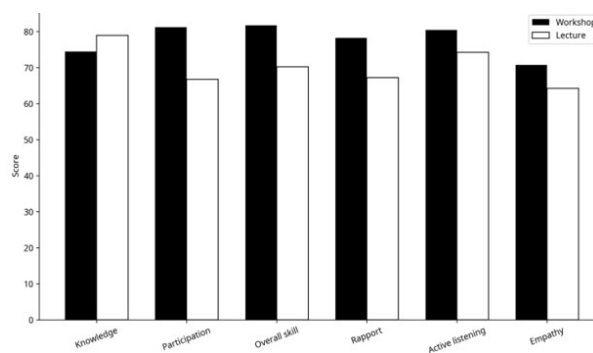
$p<0.001$), suggesting that lectures may be more effective for immediate cognitive knowledge acquisition. However, workshop participants scored significantly higher across all domains of performance and communication skills. Participation in discussion and response to questions was markedly better in the workshop group (81.25 $\pm$ 4.02 vs. 66.75 $\pm$ 3.78; mean difference=14.50; $t=30.20$; $p<0.001$). Overall interviewing skill was also superior in the workshop group (81.75 $\pm$ 5.21 vs. 70.25 $\pm$ 4.89; mean difference=11.50; $t=18.50$; $p<0.001$).

For specific domains of psychiatric interviewing, the workshop group consistently outperformed the lecture group. Rapport building (78.25 $\pm$ 5.02 vs. 67.25 $\pm$ 4.75; mean difference=11.00; $t=18.29$; $p<0.001$), active listening (80.50 $\pm$ 4.85 vs. 74.25 $\pm$ 4.55; mean difference=6.25; $t=10.80$; $p<0.001$), and empathy (70.75 $\pm$ 5.25 vs. 64.25 $\pm$ 5.10; mean difference=6.50; $t=10.20$; $p<0.001$) were all significantly higher among workshop students, as shown in Figure 3.

Taken together, these findings demonstrate that while interactive lectures may provide advantages in immediate knowledge acquisition, workshop-based instruction substantially enhances student engagement, communication, and clinical interviewing skills, highlighting its pedagogical effectiveness in psychiatric training.

Table 2 Comparison of course outcomes between workshop and interactive lecture cohorts using independent t-tests

Outcome	Workshop Mean $\pm$ SD	Interactive lecture Mean $\pm$ SD	Mean difference	t-statistic	p-value
Student's evaluation					
Overall satisfaction	94.62 $\pm$ 2.82	86.82 $\pm$ 2.31	7.80	24.67	<0.001
Perceived learning effectiveness	93.46 $\pm$ 4.28	92.23 $\pm$ 3.52	1.23	2.56	0.011
Application of knowledge	90.82 $\pm$ 3.43	82.34 $\pm$ 2.65	8.48	22.58	<0.001
Confidence in interviewing patients	87.21 $\pm$ 4.02	79.45 $\pm$ 3.81	7.76	16.10	<0.001
Educator's evaluation					
Knowledge level after psychiatric interview training	74.50 $\pm$ 3.57	79.00 $\pm$ 3.53	-4.50	-10.29	<0.001
Participation in discussion and response to questions	81.25 $\pm$ 4.02	66.75 $\pm$ 3.78	14.50	30.20	<0.001
Overall interviewing skill	81.75 $\pm$ 5.21	70.25 $\pm$ 4.89	11.50	18.50	<0.001
Rapport building	78.25 $\pm$ 5.02	67.25 $\pm$ 4.75	11.00	18.29	<0.001
Active listening	80.50 $\pm$ 4.85	74.25 $\pm$ 4.55	6.25	10.80	<0.001
Empathy	70.75 $\pm$ 5.25	64.25 $\pm$ 5.10	6.50	10.20	<0.001

**Figure 2** Comparison of student-evaluated outcomes between workshop and interactive lecture**Figure 3** Comparison of educator-evaluated outcomes between workshop and interactive lecture

Discussion

This study provides compelling evidence that workshop-based instruction is more effective than interactive lectures in enhancing key aspects of psychiatric interviewing competence among undergraduate medical students. Student evaluations revealed that workshops yielded significantly higher levels of satisfaction, confidence, and perceived application of knowledge, while educator evaluations further confirmed superior performance in communication and interviewing skills. Notably, the most pronounced improvements were observed in rapport building, active listening, empathy, and overall interviewing competence, which are fundamental not only to psychiatric care but also to patient-centered medical practice. These findings align with contemporary literature emphasizing that experiential, learner-centered teaching methodologies foster deeper engagement, reflection, and internalization of skills beyond simple knowledge acquisition^{6,7}. Through their immersive design, workshops provide opportunities for practice, immediate feedback, and guided reflection, thereby equipping students with the ability to engage patients on both cognitive and emotional levels⁸. Recent studies in health professions education echo this conclusion, showing that simulation-based and experiential pedagogies improve students' readiness for clinical encounters and enhance their professional identity formation. For example, a realist review in 2025 highlighted that longitudinal, integrative, and experiential experiences consistently yield stronger outcomes in both skills and attitudes toward patient care⁹.

At the same time, the results demonstrated that interactive lectures produced higher post-training knowledge scores than workshops. This suggests that lectures may remain advantageous for immediate cognitive knowledge acquisition, particularly in consolidating foundational content. Such findings underscore the pedagogical principle that different instructional methods may suit different learning objectives. While workshops are particularly effective in developing higher-order competencies—application, analysis, and evaluation—interactive lectures continue to play a valuable role in delivering factual knowledge, particularly when they incorporate active elements such as questioning and structured discussion¹⁰. This distinction resonates with Bloom's revised taxonomy, highlighting the complementary nature of lecture-based and experiential approaches within a balanced medical curriculum. Recent evidence supports this synergy: a 2024 systematic review on video- and lecture-based learning reported significant effects on declarative knowledge acquisition, but limited effects on higher-order skills unless combined with interactive or reflective components¹¹. These findings emphasize that the strategic integration of lectures and workshops may maximize learning efficiency by matching teaching methods with specific educational outcomes¹².

The domain-specific gains observed in the workshop group further reinforce the value of experiential learning. Rapport building, active listening, and empathy, often regarded as challenging to cultivate through didactic teaching alone, were all significantly improved through workshop participation. These results are consistent with Kolb's experiential learning theory, which underscores the importance of concrete experience, reflection, and active experimentation in promoting deeper and more sustainable learning^{13,14}. By positioning students as active participants

rather than passive recipients, workshops stimulate critical thinking, clinical reasoning, and the transfer of skills to real-world patient interactions¹⁵. This is further supported by updated evidence in medical education, where immersive, role-play-based workshops have been shown to strengthen students' confidence in handling complex patient scenarios and to improve long-term retention of communication skills¹⁶.

Furthermore, subjective learner outcomes strengthen the case for workshops as a pedagogical strategy. Workshop participants reported higher satisfaction and confidence, as well as a stronger perception of their ability to apply skills in clinical settings. These findings align with prior research showing that simulation-based, interactive environments enhance learner engagement, reduce performance-related anxiety, and improve preparedness for emotionally demanding patient encounters, particularly in psychiatric practice^{17,18}. Recent scholarship also emphasizes the affective domain of learning in medical education, with evidence suggesting that experiential training not only builds skills but also enhances empathy, resilience, and patient-centered attitudes¹⁹⁻²¹. These subjective benefits, though more difficult to measure, are increasingly recognized as vital to the holistic development of medical students.

Taken together, these findings suggest that workshop-based learning offers substantial pedagogical advantages in cultivating communication and interviewing skills, whereas lecture-based instruction continues to support knowledge acquisition. Rather than viewing these methods as competing, they should be seen as complementary. In line with global trends in medical education²², competency-based and outcomes-driven curricula that integrate both approaches are likely to yield the most well-rounded physicians. By balancing factual knowledge with immersive skill development, medical schools can produce clinicians who are both technically competent and empathetically attuned, thereby advancing the quality of patient care^{23,24}.

Several limitations must be acknowledged. First, the single-institution design may limit generalizability to other academic or cultural contexts. Second, while standardized patients provided controlled evaluation conditions, they may not fully reflect the complexity of real-world clinical encounters or capture long-term skill retention. Third, outcomes were measured only immediately after the intervention, without longitudinal follow-up to assess sustained knowledge retention, clinical application, or behavior change. Fourth, although the instruments used demonstrated acceptable validity and reliability, they were originally developed for routine course evaluation rather than research purposes, raising concerns about measurement precision, psychometric calibration, and susceptibility to biases such as rater leniency/severity, halo effects, inconsistent rubric adherence, and the influence of non-content factors (e.g., instructor personality, course difficulty). In addition, validation of the instruments was conducted within the same population as the study cohorts, which may have introduced risks of overfitting and reduced external validity. Fifth, recall bias from retrospective data and threats to internal validity exist, as no baseline data were collected on prior knowledge, attitudes, or generational cohort differences, and no adjustments were made for these potential confounders. Students with factors potentially affecting outcome ratings (such as mental disorders, absenteeism, and major academic difficulties) were not

excluded, which may have further confounded the results. The absence of internal controls may have allowed inherent differences between groups to influence outcomes. Moreover, evaluators were not blinded to group allocation, which could have introduced rater bias, particularly for subjective measures such as participation, empathy, and confidence. Missing data were excluded from the analysis, potentially reducing robustness. Finally, while statistically significant, the findings align closely with established pedagogical theory, representing a relatively low-novelty contribution, and the absence of multi-institutional or longitudinal validation further limits the advancement of the field.

Future research should employ a true experimental design with random allocation and parallel-group comparisons within the same academic period to minimize selection bias and cohort effects. Baseline learner characteristics (e.g., prior knowledge, attitudes, clinical exposure) should be measured and statistically controlled to enhance group comparability. Assessments should extend beyond immediate post-course evaluation to include long-term follow-up of knowledge retention, clinical application, and behavioral change, using psychometrically validated tools and rater calibration to minimize bias. Multi-institutional studies across diverse cultural and academic settings are recommended to strengthen external validity. Finally, future investigations should aim for higher-novelty contributions by integrating innovative instructional designs such as virtual patient simulations, AI-assisted feedback systems, or interprofessional team-based workshops to advance both pedagogical theory and clinical education practice.

Conclusions

This study suggests that workshop-based learning could be more effective in enhancing core psychiatric interviewing skills among undergraduate medical students. While interactive lectures have demonstrated value in fostering cognitive knowledge acquisition, the active, participatory nature of workshops may be more suitable for cultivating students' practical competencies, particularly in applying knowledge, establishing rapport, engaging in active listening, and demonstrating empathy. Although empathy scores were relatively lower compared to other domains, this skill remains an essential component of effective psychiatric care. The findings provide evidence in favor of integrating workshop-based methodologies as an element of undergraduate curricula for psychiatry and communication skills. It is recommended that educators adopt a strategically blended instructional approach that combines the strengths of lecture-based and experiential learning formats. Future evaluations could examine the longer-term impact of this approach on students' skill retention and application, such as in post-graduation settings.

Ethical Approval

The study was approved by the Institutional Human Research Ethics Committee of Bangkok (protocol code S015hc/68_NA; approval date: 28 May 2025). Informed consent was obtained from all participants or their legal representatives.

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บทความวิจัย

ประสิทธิผลของการอบรมเชิงปฏิบัติการที่พัฒนาขึ้น เปรียบเทียบกับการบรรยายแบบมีปฏิสัมพันธ์ ในหัวข้อการซักประวัติทางจิตเวช ในนักศึกษาแพทย์ สำนักวิชาแพทยศาสตร์ มหาวิทยาลัยแม่ฟ้าหลวง

กัณตพัฒน์ ราชไชยา

กลุ่มงานจิตเวช โรงพยาบาลเจริญกรุงประชารักษ์

คำสำคัญ

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บทคัดย่อ

การเรียนรู้ด้านการซักประวัติทางจิตเวชเป็นหัวข้อที่สำคัญในการนำไปใช้กับผู้ป่วยจิตเวช ซึ่งต้องอาศัยทั้งความรู้และทักษะ จึงเป็นที่มาในการศึกษาและพัฒนากระบวนการสอนที่มีประสิทธิภาพสูงสุดในการพัฒนาความรู้และทักษะของนักศึกษาแพทย์ จึงทำให้เกิดความสนใจในการศึกษาวิจัย โดยมีวัตถุประสงค์เพื่อเปรียบเทียบประสิทธิผลของการสอนแบบอบรมเชิงปฏิบัติการ (workshop) ที่ได้พัฒนาขึ้น และการบรรยายแบบมีปฏิสัมพันธ์ (interactive lecture) ในหัวข้อการซักประวัติทางจิตเวช การวิจัยนี้เป็นการศึกษาเชิงสังเกตย้อนหลัง โดยใช้ข้อมูลของนักศึกษาแพทย์ชั้นปีที่ 4 ทั้งหมดจำนวน 264 คน จากมหาวิทยาลัยแม่ฟ้าหลวง เครื่องมือที่ใช้ประเมิน ประกอบด้วย แบบประเมินความพึงพอใจหลังการเรียนรู้ แบบประเมินความรู้และทักษะการซักประวัติผู้ป่วยจิตเวช ข้อมูลถูกเก็บจากนักศึกษาสองกลุ่ม ได้แก่ กลุ่ม interactive lecture (ปี 2559-2562) และกลุ่ม workshop (ปี 2563-2567) การวิเคราะห์ข้อมูลใช้สถิติ independent t-test โดยผลการศึกษพบว่า นักศึกษาที่เรียนแบบ workshop มีคะแนนสูงกว่ากลุ่ม interactive lecture อย่างมีนัยสำคัญทางสถิติ ในด้านทักษะการสร้างสัมพันธภาพกับผู้ป่วย และการฟังอย่างตั้งใจ ($p < 0.001$) แต่ในหัวข้อการแสดงความเข้าใจผู้ป่วยยังมีคะแนนค่อนข้างต่ำทั้ง 2 วิธี ในขณะที่กลุ่ม interactive lecture มีคะแนนความรู้เชิงทฤษฎีสูงกว่า ($p < 0.001$) โดยสรุป workshop เสริมทักษะได้ดีกว่า ส่วน interactive lecture พัฒนาความรู้ได้ดีกว่า ฉะนั้นจากงานวิจัยนี้แสดงให้เห็นว่าการบูรณาการการเรียนรู้แบบ workshop และ interactive lecture ช่วยเสริมสร้างให้นักศึกษาแพทย์มีทั้งทักษะและองค์ความรู้ในการซักประวัติทางจิตเวชได้อย่างมีประสิทธิภาพ ส่วนทักษะด้านการเข้าใจผู้ป่วยยังคงต้องพัฒนาต่อไป และงานวิจัยชิ้นนี้น่าจะเป็นประโยชน์ในการพัฒนาหลักสูตรการเรียนรู้ด้านจิตเวชศาสตร์ต่อไป

ORIGINAL ARTICLE

Validity and Reliability of the Res-Rhythm: A Prototype Portable Respiratory Rate Measurement System in Healthy Subjects

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ABSTRACT

Respiratory rate is one of the important vital signs, typically assessed by observing the number of breaths per minute. This can result in measurement errors and variability between observers. Furthermore, commercially available respiratory rate measurement devices tend to be expensive. This study aimed to develop a portable prototype system for measuring respiratory rate, consisting of a chest belt sensor and a display application. Validity was tested by comparing it with a BIOPAC device, and reliability was tested using the retest method in 29 healthy volunteers with an average age of 21.61 ± 2.24 years. The test was conducted during a 5-minute rest period and a 5-minute exercise period, which involved marching in place, for a total of 10 minutes, repeated twice. Validity was analyzed using Pearson's correlation coefficient (r), and reliability was analyzed using the intraclass correlation coefficient (ICC) at the 95% confidence interval. The study found that the prototype device demonstrated very high validity during both rest ($r=0.94$, $p<0.001$) and exercise ($r=0.90$, $p<0.001$) when compared to the BIOPAC device. The average difference between the two devices was -0.35 ± 1.5 breaths per minute (2.01%) during rest and -0.81 ± 1.90 breaths per minute (4.18%) during exercise. When analyzing test-retest reliability, the prototype system showed good reliability (ICC=0.75, $p<0.01$) at rest and moderate reliability (ICC=0.57, $p<0.01$) during exercise. The average difference between the two measurements was -1.11 ± 3.89 breaths per minute (6.78%) at rest and -0.70 ± 4.50 breaths per minute (3.81%) during exercise. In conclusion, the prototype system demonstrated acceptable levels of validity and reliability. Additionally, it can be further developed into a portable respiratory rate measurement device for clinical and research applications.

Introduction

Respiratory rate (RR) is one of the vital signs that reflects the general physiological status of the body. RR can deviate from normal values, which vary across different age groups, when the body experiences illness or responds to internal stressors¹. Moreover, RR values measured during exercise can serve as an indicator for monitoring exercise intensity and fatigue, reflecting differences in individual exercise tolerance^{2,3}. Previous studies showed that RR can be used to predict cardiac arrest and diagnose the severity of pneumonia in children and adults, as well as in patients with coronavirus disease 2019 (COVID-19)^{4,7}. Clinically, RR is commonly measured by counting the number of breaths per minute, defined as one inspiration and one expiration, observed through chest expansion and relaxation. In addition, the assessor may evaluate the depth, rhythm, and breathing pattern to detect respiratory abnormalities. However, manual counting is prone to high variability between observers because it depends on the observer's skill and experience, as well as the duration of observation.

Consequently, RR measurements can differ even when taken from the same individual⁸.

To address these issues, RR measuring devices have been developed for convenience and to minimize measurement errors, using different approaches. Direct methods include the piezoelectric respiratory sensor, impedance pneumography, and capnography⁹⁻¹³. Indirect methods estimate RR from electrocardiograms (ECG) or photoplethysmograms (PPG)^{14,15}. However, these devices are not widely used in clinical practice due to their relatively high cost, complex installation, and bulky size, which limit portability and field application. Recently, a prototype portable device for heart rate and RR measurement with a mobile display application was developed in Thailand¹⁰. This prototype demonstrated accuracy in measuring RR compared to an ECG monitor. Nonetheless, it showed low sensitivity in detecting chest expansion, as users needed to breathe deeply to the level of the diaphragm for capturing respiratory signals. The sensor unit was relatively large, limiting its usability in field settings and during exercise. In

addition, the display program could report only waveforms and RR, without providing data on the inspiration-expiration duration parameters essential for evaluating breathing patterns and guiding respiratory training. The previous prototype employed a strain-gauge-based respiratory sensor connected via an IOIO-Q interface board, which detected thoracic circumference changes through variations in electrical resistance. In contrast, the current study utilized a piezoelectric (PZT) respiratory sensor integrated with an Arduino microcontroller, which detects chest wall motion by converting mechanical deformation into voltage signals. This piezoelectric configuration provides higher sensitivity and faster response compared with the strain-gauge sensor¹⁶, while the Arduino-based system enhances signal stability, portability, and wireless data acquisition. Furthermore, the present design allows real-time estimation of additional respiratory parameters, including the inspiration-to-expiratory (I:E) ratio, during dynamic exercise.

This study aimed to develop a prototype portable RR monitoring system, consisting of a respiratory belt sensor and a mobile application that displays respiratory parameters, including respiratory rate and inspiration-expiration duration, via portable electronic devices connected through Wi-Fi. The prototype was tested in healthy volunteers and

compared with a BIOPAC device. This system may provide a basis for developing clinical and research applications for RR measurement.

Materials and Methods

Prototype Development

This study developed a prototype portable respiratory rate monitoring system, named Res-Rhythm, which consisted of two main components, including a respiratory belt sensor that detects thoracic movements during breathing, and a display application (Figure 1). The system operates in three main steps: (1) A piezo-electric respiratory sensor, attached to a respiratory belt, detects signals from chest expansion and relaxation. These signals are transmitted to a microcontroller connected to a Wi-Fi network. (2) The sensor data are then sent to a server, where they are stored and processed using a Microsoft SQL Server database and PHP-based programs. (3) The processed data are displayed through an application accessible via an internet browser on the World Wide Web. The application presents respiratory-related variables, including respiratory waveform, respiratory rate, inspiration time, expiration time, and the I:E ratio.

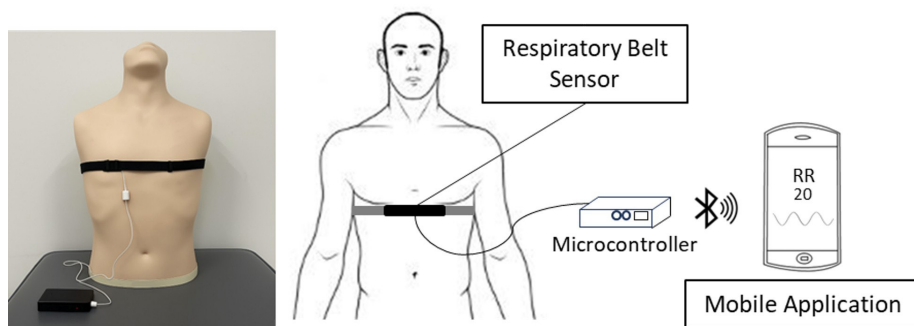


Figure 1 Prototype of a portable respiratory rate measuring system (Res-Rhythm)

Participants

This study recruited twenty-nine healthy volunteers (aged 20-60 years) through public announcements at Mae Fah Luang University and nearby communities. Individuals who expressed interest underwent screening using a questionnaire and a brief physical assessment to ensure that they met the inclusion criteria. The inclusion criteria were individuals with no self-reported or physician-diagnosed medical conditions, who were able to communicate effectively, and who could follow instructions. Exclusion criteria included those with a history of diagnosed respiratory diseases (e.g., asthma), cardiovascular diseases (e.g., ischemic heart disease, coronary artery disease, or valvular heart disease), chest or rib injuries with wounds or fractures located beneath the nipples or at the level of the sternum, neurological disorders affecting respiration (e.g., spinal cord injury, Guillain-Barré syndrome, amyotrophic lateral sclerosis, or myasthenia gravis), and movement disorders affecting standing or walking.

Validity and Reliability Testing

After providing written informed consent, volunteers appeared at the laboratory on a scheduled date. Upon arrival, participants were asked to rest in a seated position for at least 5 minutes. Personal information was collected, including sex, age, weight, height, body mass index, and medical history. Vital signs, including blood pressure, heart rate, respiratory rate, and body temperature, were measured over approximately 20 minutes to identify potential contraindications or precautions for exercise testing.

Following screening, participants were fitted with the prototype respiratory belt sensor and the BIOPAC device (BIOPAC MP36 Systems, Goleta, CA). Both straps were positioned below the nipples around the level of the fourth intercostal space, ensuring they did not overlap (Figure 2). Electrodes were applied to the chest wall to record lead II ECG. An arm cuff was placed on the left upper arm, and a finger plethysmography device was attached. All sensors were connected to a bedside monitor (Life Scope®, Nihon

Kohden, Japan). Preparation took approximately 10 minutes. Tests were conducted individually in a quiet laboratory at a controlled temperature between 23-25 °C.

The testing protocol included three stages: (1) Resting stage: Participants sat upright on a chair with back support and feet flat on the floor, breathing normally. RR from the prototype and BIOPAC device, as well as inspiration/expiration time and heart rate, were recorded at baseline (0 minute) and every minute for 5 minutes. (2) Exercise stage: At 6th minute, participants performed the Spot Marching Exercise (SME) by marching in place at a cadence of 70 steps per minute, with hip flexion of 70° and arm swing of at least 90°. This activity increased breathing rate to test the validity

and reliability of the prototype during exercise. RR and heart rate were recorded at baseline (minute 0) and every minute for 5 minutes, continuing until minute 10. (3) Recovery stage: Participants rested for at least 30 minutes until RR, heart rate, and blood pressure returned to baseline. The testing protocol from stages (1) and (2) was then repeated.

Validity testing was performed by comparing mean RR values obtained from the prototype and the standard device during both the 5-minute resting and 5-minute exercise phases. Reliability testing was assessed by comparing mean RR values between the first and second trials during rest and exercise.

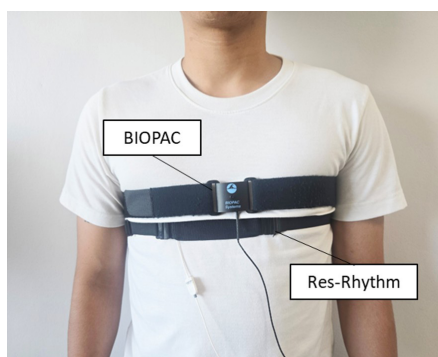


Figure 2 Setup of the respiratory belt sensor of Res-Rhythm and BIOPAC device on a subject for validity and reliability testing.

Statistical Analysis

All data were analyzed using SPSS version 20.0, with a significance level set at $p \leq 0.05$. The Shapiro-Wilk test was used to assess data distribution. Descriptive statistics (frequency distribution, mean, standard deviation, and percentage) were applied to participant characteristics, including age, blood pressure, heart rate, respiratory rate, and body temperature at rest. Comparisons of RR between the prototype and the BIOPAC device were performed using a paired t-test for normally distributed data and the Wilcoxon signed-rank test for non-normally distributed data. To supplement the interpretation of the mean values, standard error of mean (SEM) was calculated as SD divided by the square root of the sample size ($SEM = SD/\sqrt{n}$). Validity analysis was conducted using Pearson's correlation coefficient (r): values of 0.00-0.30 indicated no correlation, 0.30-0.50 low correlation, 0.50-0.70 moderate correlation, 0.70-0.90 high correlation, and 0.90-1.00 very high correlation. Agreement between devices was examined using the Bland-Altman test. For each comparison, the mean difference, the standard error of the mean difference, and the 95% limits of agreement were calculated to evaluate the magnitude and precision of measurement differences (SEdiff). Reliability analysis was achieved using intraclass correlation coefficients (ICC) from repeated tests, applying the ICC (3,1) model (two-way mixed-effects model, single measures) since there was only one assessor. ICC values less

than 0.5 indicated poor reliability, while values from 0.5 to 0.74 indicated moderate reliability, values from 0.75 to 0.89 indicated good reliability, and values from 0.9 to 1.0 indicated excellent reliability. Agreement between the two test sessions was examined using the Bland-Altman test, including mean difference, SEdiff, and the 95% limits of agreement.

Results

Participant characteristics

A total of 29 healthy volunteers participated in this study, consisting of 11 males (37.93%) and 18 females (62.07%). The mean age of the participants was 21.61 ± 2.24 years, with an average body weight of 70.83 ± 17.32 kg, height of 165.38 ± 8.45 cm, and body mass index (BMI) of 25.75 ± 5.27 kg/m². The participants' average resting heart rate was 79.07 ± 11.54 beats per minute, while the average systolic and diastolic blood pressures were 111.75 ± 15.27 mmHg and 75.89 ± 11.68 mmHg, respectively.

Comparison of RR between the BIOPAC Device and the Prototype System

When comparing the mean RR between the standard device and the prototype system, no statistically significant differences were found during either the resting or exercise phases in both the first and second trials (Table 1).

Table 1 Comparison of respiratory rate between the BIOPAC device and the prototype of the portable respiratory rate measuring system (Res-Rhythm)

Variables	BIOPAC device		Res-Rhythm		<i>p</i> -value
	Mean ± SD	SEM	Mean ± SD	SEM	
Measurement 1					
At rest					
- Respiratory rate (breaths/min)	16.83 ± 3.21	0.60	16.54 ± 3.94	0.73	0.270
- Inspiratory time (seconds)	-	-	1.46 ± 0.31	0.06	-
- Expiratory time (seconds)	-	-	2.30 ± 0.65	0.12	-
- I:E ratio	-	-	1:1.61	-	-
During exercise					
- Respiratory rate (breaths/min)	19.28 ± 2.91	0.54	18.41 ± 3.35	0.62	0.058
- Inspiratory time (seconds)	-	-	1.27 ± 0.21	0.04	-
- Expiratory time (seconds)	-	-	1.99 ± 0.46	0.09	-
- I:E ratio	-	-	1:1.59	-	-
Measurement 2					
At rest					
- Respiratory rate (breaths/min)	17.88 ± 4.07	0.76	17.45 ± 4.73	0.88	0.172
- Inspiratory time (seconds)	-	-	1.37 ± 0.46	0.09	-
- Expiratory time (seconds)	-	-	2.28 ± 0.93	0.17	-
- I:E ratio	-	-	1:1.76	-	-
During exercise					
- Respiratory rate (breaths/min)	19.70 ± 3.50	0.65	18.92 ± 4.90	0.91	0.055
- Inspiratory time (seconds)	-	-	1.13 ± 0.32	0.06	-
- Expiratory time (seconds)	-	-	2.09 ± 0.54	0.10	-
- I:E ratio	-	-	1:1.93	-	-

Data were analyzed using the paired t-test; $p < 0.05$ was considered statistically significant. Abbreviations: I, inspiratory time; E, expiratory time; SD, standard deviation; SEM, standard error of the mean.

Validity Testing

Analysis of validity between the two devices using Pearson's correlation coefficient showed that respiratory rate values from the prototype and the BIOPAC device were very highly correlated both at rest ($r = 0.94$, $p < 0.001$) (Figure 3A) and during exercise ($r = 0.90$, $p < 0.001$) (Figure 3B). The mean difference in respiratory rate between the two devices at rest was -0.35 ± 1.5 breaths per minute (2.01%), with a standard

error of the difference of 0.28 and limits of agreement at the 95% confidence interval ranging from -3.30 to $+2.60$ breaths per minute (Figure 3C). During exercise, the mean difference between the two devices was -0.81 ± 1.90 breaths per minute (4.18%), with a standard error of the difference of 0.35 and limits of agreement at the 95% confidence interval ranging from -4.50 to $+2.90$ breaths per minute (Figure 3D).

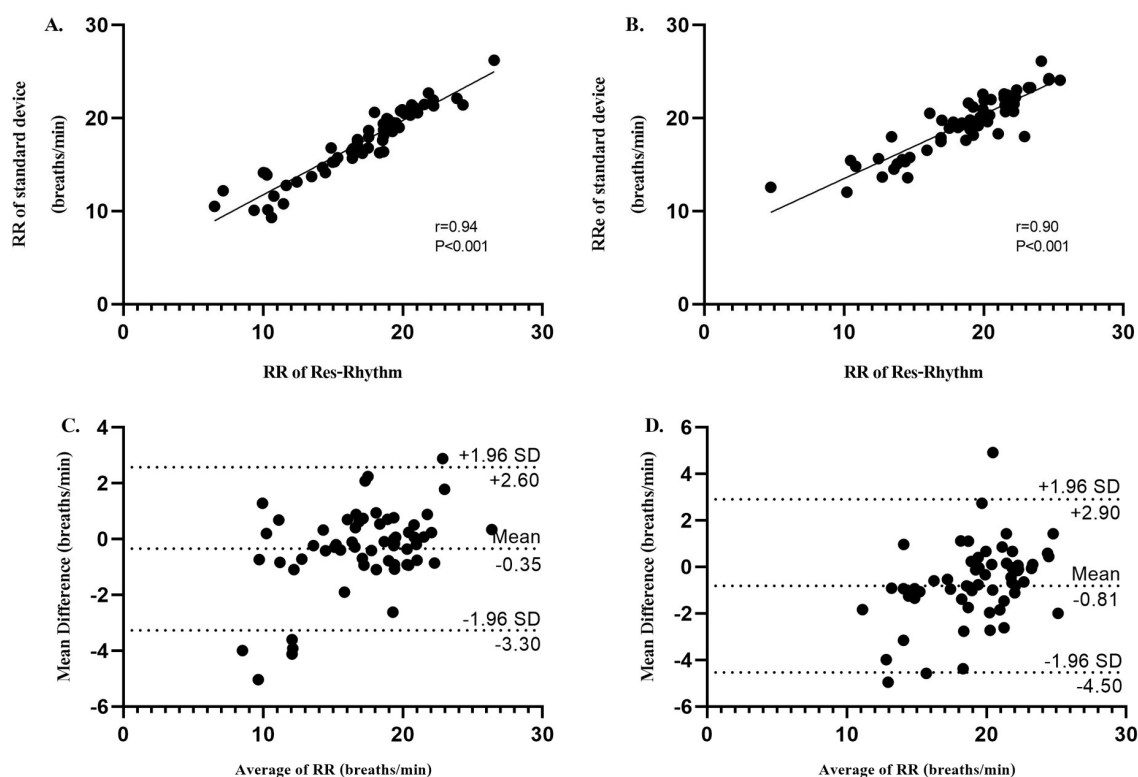


Figure 3 Correlations (A, B) and Bland–Altman plots (C, D) comparing respiratory rate (RR) measurements obtained from the BIOPAC device and the prototype of the portable respiratory rate measuring system (Res-Rhythm) at rest (A, C) and during exercise (B, D).

Reliability Testing

Analysis of the test–retest reliability of the prototype portable respiratory rate monitoring system, performed twice during rest and exercise using the intraclass correlation coefficient (ICC), demonstrated that the prototype showed good reliability at rest and moderate reliability during exercise (Table 2). The mean difference in respiratory rate between the two test sessions at rest was -1.11 ± 3.89 breaths

per minute (6.78%), with a standard error of the difference of 0.72 and limits of agreement at the 95% confidence interval ranging from -8.73 to $+6.50$ breaths per minute (Figure 4A). During exercise, the mean difference was -0.70 ± 4.50 breaths per minute (3.81), with a standard error of the difference of 0.84 and limits of agreement at the 95% confidence interval ranging from -9.60 to $+8.20$ breaths per minute (Figure 4B).

Table 2 Reliability of the prototype of the portable respiratory rate measuring system (Res-Rhythm)

Variables	Mean $\pm$ SD	ICC (95% CI)
Respiratory rate at rest (breaths/min)		
Measurement 1	16.54 ± 3.94	0.75*
Measurement 2	17.45 ± 4.73	(0.47 - 0.88)
Respiratory rate during exercise (breaths/min)		
Measurement 1	18.41 ± 3.35	0.57*
Measurement 2	18.92 ± 4.90	(0.10 - 0.80)

ICC, intraclass correlation coefficient; 95% CI, 95% Confidence Interval; SD, standard deviation; *Statistically significant difference at $p<0.05$.

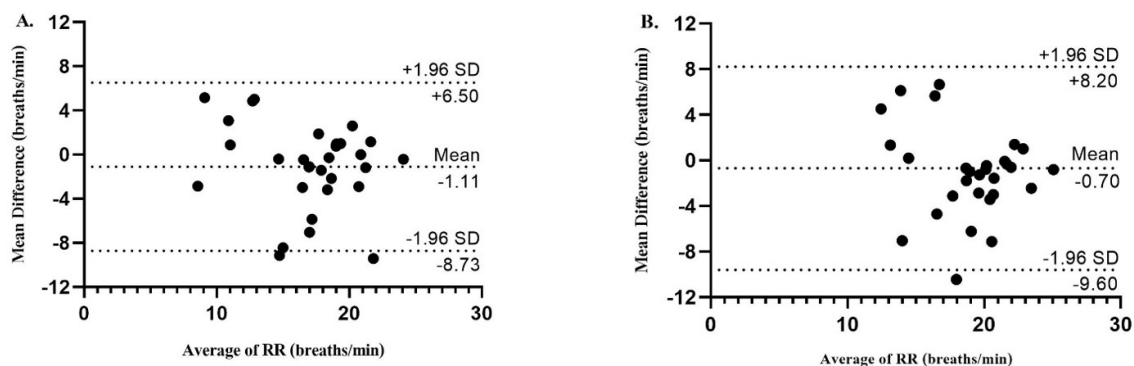


Figure 4 Bland–Altman plots comparing respiratory rate measurements obtained using the prototype of the portable respiratory rate monitoring system between the first and second measurements at rest (A) and during exercise (B).

Discussion

This study aimed to develop a prototype portable RR monitoring system and evaluate its validity compared with a BIOPAC device, as well as its reliability from repeated measurements in 29 healthy volunteers. The findings demonstrated that the RR values obtained from the prototype and the BIOPAC device did not differ significantly, both at rest and during exercise. Moreover, the prototype exhibited high validity and moderate-to-good reliability, suggesting that it could be further developed for use in respiratory monitoring.

In this study, validity testing involved comparison with a BIOPAC device that uses the same principle of RR measurement: an elastic respiratory belt sensor that detects mechanical forces from thoracic expansion and relaxation during breathing. Testing was conducted both at rest and during exercise to determine whether the new prototype could perform consistently under different conditions of physical activity. The results showed a very high correlation between the two devices, indicating the strong validity of the prototype. These findings are consistent with a previous study by Yuenyongchaiwat et al.¹⁰, which developed and tested a similar respiratory measuring device against a bedside monitor that calculated RR from ECG signals. They reported a high correlation and a mean difference of -0.23 breaths per minute, comparable to the mean difference of -0.35 breaths per minute in the present study. This suggests that the current prototype achieves a comparable level of validity. However, unlike the previous study, which did not test during exercise, the present study demonstrated that the prototype maintains validity during increased physical activity levels. In comparison, Singh et al.¹² developed an RR monitor using impedance pneumography and reported a mean difference of 0.05 breaths per minute compared with observer-based breath counting. Although this shows smaller differences, their reference standard relied on manual counting, which is prone to higher variability, unlike the sensor-based standard device used in the present study.

Reliability testing indicated that the prototype system demonstrated good reliability at rest, reflecting stable measurement performance in static conditions. This finding is consistent with Nazari et al.¹⁷, who reported good-to-excellent reliability of chest-strap-based RR monitors, both at rest and during treadmill exercise. In this study, reliability during exercise was moderate, which may be explained by

the type of exercise employed. While Nazari et al.¹⁷ used treadmill running, where thoracic movement is primarily driven by breathing, the current study applied SME involving arm swinging and hip flexion¹⁸. Such movements may have caused additional tension in the chest wall muscles and mechanical artifacts that interfered with sensor detection, thereby reducing reliability during exercise. It is also possible that these motion-induced artefacts affected the estimation of I:E ratio. The greater upper-body movement during SME could have distorted the respiratory waveform, leading to differences in the calculated I:E ratio between the two exercise bouts. Therefore, the inconsistency in I:E ratio (1:1.59 vs 1:1.93) may not fully reflect true changes in breathing pattern but rather the influence of motion artefacts on the chest sensor signal. Nevertheless, the mean differences of RR between the two trials remained within acceptable limits in the Bland–Altman plots.

The prototype portable RR monitoring system in this study may provide a practical basis for developing accurate devices for both research and clinical applications. However, certain limitations must be addressed in future work. First, reliability during physical activity requires improvement, possibly through the development of sensors optimized for capturing respiratory signals during dynamic movement or enhanced signal-processing algorithms within the application to reduce motion artifacts. Second, the stability and transmission range of wireless signals between the sensor and the receiver should be improved, which would enable broader application in diverse monitoring environments. In addition, future studies should include other populations, such as older adults, patients with respiratory or cardiovascular diseases, or populations requiring close RR monitoring.

Conclusions

The newly developed prototype of a portable respiratory rate monitoring system demonstrated good validity and reliability compared with a BIOPAC device. These findings suggest that the prototype could serve as a foundation for the further development of accurate respiratory monitoring systems for future clinical and research use. Future studies should focus on improving sensor design and signal-processing algorithms to enhance measurement accuracy, particularly during dynamic conditions.

Ethical Approval

The study was approved by the Mae Fah Luang University Ethics Committee on Human Research (protocol code EC 23115-25; approval date: 21 August 2023). Informed consent was obtained from all participants or their legal representatives.

Acknowledgements

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บทความวิจัย

ความตรงและความเที่ยงของ Res-Rhythm: ต้นแบบระบบวัดอัตราการหายใจแบบพกพาในอาสาสมัครสุขภาพดี

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ต้นแบบ; การวัดอัตราการหายใจ; ความตรง; ความเที่ยง

ผู้นิพนธ์ประสานงาน

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บทคัดย่อ

การวัดอัตราการหายใจเป็นหนึ่งในสัญญาณชีพที่สำคัญในทางคลินิก โดยนิยมประเมินด้วยการสังเกตจำนวนครั้งของการหายใจ ซึ่งอาจทำให้เกิดความคลาดเคลื่อนและความแปรปรวนระหว่างผู้วัด อีกทั้งอุปกรณ์วัดอัตราการหายใจที่มีจำหน่ายในเชิงพาณิชย์ยังมีราคาสูง การศึกษาในครั้งนี้จึงมีวัตถุประสงค์เพื่อพัฒนาต้นแบบของระบบการวัดอัตราการหายใจแบบพกพา ประกอบไปด้วย เซนเซอร์สายรัดบริเวณหน้าอกและแอปพลิเคชันแสดงผล ทำการทดสอบความตรงเทียบกับเครื่อง BIOPAC และทดสอบความเที่ยงด้วยการวัดซ้ำในอาสาสมัครสุขภาพดี จำนวน 29 คน อายุเฉลี่ย 21.61 ± 2.24 ปี โดยทำการทดสอบขณะพัก 5 นาที และขณะออกกำลังกายด้วยการแกว่งแขนและย่อท่าอยู่กับที่ 5 นาที รวมทั้งหมด 10 นาที จำนวน 2 รอบ วิเคราะห์ความตรงด้วยค่าสัมประสิทธิ์สหสัมพันธ์แบบเพียร์สัน (Pearson's correlation coefficient, r) และความเที่ยงด้วยค่าสัมประสิทธิ์สหสัมพันธ์ภายในกลุ่ม (Intraclass correlation coefficient, ICC) ที่ระดับความเชื่อมั่น 95% ผลการศึกษาพบว่าอุปกรณ์ต้นแบบมีความตรงอยู่ในระดับสูงมากทั้งในขณะพัก ($r=0.94, p<0.001$) และขณะออกกำลังกาย ($r=0.90, p<0.001$) เมื่อเทียบกับเครื่อง BIOPAC โดยมีค่าเฉลี่ยความแตกต่างระหว่าง 2 เครื่องในขณะพักเท่ากับ -0.35 ± 1.5 ครั้งต่อนาที (2.01%) และขณะออกกำลังกายเท่ากับ -0.81 ± 1.90 ครั้งต่อนาที (4.18%) เมื่อวิเคราะห์ความเที่ยงในการวัดซ้ำพบว่า ต้นแบบของระบบการวัดอัตราการหายใจมีความเที่ยงอยู่ในระดับดี (ICC=0.75, $p<0.01$) ในขณะพักและมีความเที่ยงในระดับปานกลาง (ICC=0.57, $p<0.01$) ในขณะออกกำลังกาย โดยมีค่าเฉลี่ยความแตกต่างระหว่างการวัด 2 ครั้ง ขณะพักเท่ากับ -1.11 ± 3.89 ครั้งต่อนาที (6.78%) และขณะออกกำลังกายเท่ากับ -0.70 ± 4.50 ครั้งต่อนาที (3.81%) จึงสามารถสรุปได้ว่าต้นแบบของระบบการวัดอัตราการหายใจมีความตรงและความเที่ยงอยู่ในระดับที่ยอมรับได้ ซึ่งอาจนำมาใช้เป็นแนวทางในการพัฒนาอุปกรณ์วัดอัตราการหายใจแบบพกพาที่สามารถนำมาใช้ในทางคลินิกและการศึกษาวิจัยต่อไปได้

ORIGINAL ARTICLE

Effect of General Anesthesia Induction with a Combination of Propofol and Etomidate Versus Propofol Alone on I-gel Laryngeal Mask Airway Insertion

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KEYWORDS

propofol; etomidate; combination of propofol and etomidate; I-gel LMA insertion; LMA insertion conditions

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ABSTRACT

Propofol is one of the most commonly used anesthetic agents for laryngeal mask airway (LMA) insertion, but it is associated with unwanted complications such as hemodynamic instability and cardiovascular complications. Various intravenous anesthetic agents in combination with propofol have been studied in an attempt to minimize these complications. This prospective, randomized, double-blind, controlled study aimed to compare the effect of a combination of propofol and etomidate versus propofol alone on hemodynamics, LMA insertion conditions, and first-attempt success rate for I-gel LMA insertion. The participants comprised 62 adults aged 18–64 years of either sex with American Society of Anesthesiologists (ASA) physical status I-II who underwent elective surgery under general anesthesia at Kumphawapi Hospital, Udon Thani, Thailand, between May 2025 and August 2025. Patients were randomly allocated to the propofol (P) group (n=31), which received propofol 2 mg/kg, or the propofol + etomidate (PE) group, which received propofol 1 mg/kg plus etomidate 0.2 mg/kg for induction. Hemodynamic parameters were recorded before induction, 1 minute after induction, after successful LMA insertion, and 3, 5 and 10 minutes after LMA insertion. Jaw relaxation, LMA insertion conditions, and first-attempt success rate were also assessed and recorded. The results showed no significant differences in mean arterial pressure (MAP), systolic blood pressure (SBP), diastolic blood pressure (DBP), or heart rate (HR) at various time points following induction between the two groups ($p>0.050$). Good jaw relaxation was observed in 23/31 patients (74.19%) in group P versus 19/31 patients (61.29%) in group PE ($p=0.277$). Overall LMA insertion conditions were comparable between groups ($p=0.785$). The first-attempt success rate of I-gel LMA insertion was 83.37% in group P and 90.32% in group PE ($p=0.307$). In conclusion, there were no significant differences between the effects of propofol 1 mg/kg combined with etomidate 0.2 mg/kg and propofol 2 mg/kg on hemodynamic stability, jaw relaxation, LMA insertion conditions, or first-attempt success rate.

Introduction

The laryngeal mask airway (LMA) is supraglottic airway device that has been widely used for airway management during general anesthesia because it causes minimal disturbances in the cardiovascular and respiratory systems¹. Insertion of the LMA requires adequate anesthetic depth to suppress airway reflexes and provide jaw relaxation, preventing patient reactions to LMA insertion². Propofol is the most commonly used induction agent for general anesthesia during LMA insertion due to its ability to suppress upper airway reflexes, rapid onset, satisfactory recovery, short half-life, rapid elimination from blood circulation resulting in minimal sedative effects, and low postoperative nausea and vomiting rate^{3,4}. The dose of propofol for induction is 2–3 mg/kg, which provides sufficient suppression of upper airway reflexes, movement

and laryngospasm commonly result in hypotension and prolonged apnea⁵. Independent of cardiovascular disease, an induction dose of 2–2.5 mg/kg produces a 25%–40% reduction in systolic blood pressure⁶. Various intravenous anesthetic agents in combination with propofol have been studied in an attempt to decrease hemodynamic instability³.

Etomidate is an ultrashort-acting intravenous anesthetic agent that interacts with gamma-aminobutyric acid type A (GABA_A) receptors by binding directly to specific sites and increasing the affinity of the inhibitory neurotransmitter GABA in the central nervous system (CNS). A common induction dose of etomidate is 0.2–0.3 mg/kg. It has minimal effects on the cardiovascular system, causing only mild reduction in peripheral vascular resistance and is not associated with histamine release. Adverse effects of etomidate include transient adrenocortical suppression

lasting 6–12 hours, mostly resolving by 48 hours, and postoperative nausea and vomiting⁷. However, etomidate as a sole anesthetic agent does not provide adequate jaw relaxation or suppression of upper airway reflexes, even when used with a narcotic^{5,8}.

Several studies have demonstrated that etomidate and etomidate–propofol admixture provide better hemodynamic stability than propofol induction. Most of these studies used propofol 2.5 mg/kg and did not compare LMA insertion conditions^{3,5,8}.

The primary objective of this study was to evaluate hemodynamic stability following induction with propofol 2 mg/kg or a combination of propofol 1 mg/kg and etomidate 0.2 mg/kg for I-gel LMA insertion. The secondary objectives were to assess the effects on LMA insertion conditions and first-attempt success rate.

Materials and Methods

This prospective, randomized, double-blind, controlled study was conducted in accordance with the Declaration of Helsinki and the International Council for Harmonisation – Good Clinical Practice (ICH-GCP) at Kumphawapi Hospital, Udon Thani, Thailand, from May 2025 to August 2025, and retrospectively registered to the Thai Clinical Trials Registry (TCTR 20260114010). All patients were informed about the study and provided written consent to participate. Sixty-two patients with American Society of Anesthesiologists (ASA) physical status I–II, aged 18–64 years and of either sex, who underwent elective surgery under general anesthesia with LMA, were enrolled into the study. Exclusion criteria were patients who refused to participate or could not communicate with the researcher; contraindication to any study drugs; pregnancy or lactation; cardiovascular disease such as ischemic heart disease, hypertension, or arrhythmia; existing pathology in the pharynx or larynx; limited mouth opening (< 2.5 cm); Mallampati score ≥ 3 ; difficult airway; body mass index (BMI) > 30 kg/m²; full stomach; reactive airway disease; known primary or secondary adrenal insufficiency; use of steroid medication by any route; sepsis; history of epilepsy or seizure disorder; glomerular filtration rate (GFR) < 30 ml/min/1.73 m²; and cirrhosis Child-Pugh B–C.

The sample size was calculated based on a previous study³, where the mean arterial pressure (MAP) after induction was 77.4 ± 12.3 mmHg in the propofol group and 86.5 ± 12 mmHg in the propofol + etomidate group. Type I error (a) was set at 0.05 and type II error (b) at 0.2 (80% power). This resulted in a sample size of 28 patients per group. To account for potential attrition, 10% was added to each group, resulting in a final sample size of 31 patients per group.

The 62 patients who met the inclusion and exclusion criteria were randomly allocated into two equal groups using block randomization generated by computer (<https://www.sealedenvelope.com/simple-randomiser/v1/lists>). The propofol group (P) received propofol 2 mg/kg (Propofol-®Lipuro 1%, B.Braun, Melsungen, Germany), and the propofol + etomidate group (PE) received propofol 1 mg/kg combined with etomidate 0.2 mg/kg (Etomidate-®Lipuro, B.Braun, Melsungen, Germany). The drugs were prepared in 20-ml syringes and diluted to 20 ml by a research assistant who was not involved in patient care. In the operating

room, the patients, anesthesiologist, and nurse anesthetist in charge of the case were unaware of group allocation and drug preparation. All patients were pre-oxygenated with 100% oxygen via face mask at flow rate of 6 L/min for 5 minutes. Standard monitoring, including electrocardiogram (EKG), non-invasive blood pressure (NIBP), and peripheral oxygen saturation (SpO₂) were applied. Vital signs were recorded every 5 minutes using a calibrated automated non-invasive blood pressure monitor. Patients were premedicated with intravenous fentanyl 1 µg/kg, 3 minutes prior to induction with propofol or propofol + etomidate admixture, administered over 20 sec according to randomization, until loss of consciousness, which was confirmed by inability to respond to verbal commands and loss of eyelash reflex. One minute after completion of study drug injection, the LMA was inserted in the sniffing position by an anesthetist nurse with experience in at least 50 I-gel LMA insertions. The I-gel LMA was chosen according to the manufacturer's recommendations⁹. Successful LMA insertion was defined as proper placement of the device, confirmed by adequate bilateral chest expansion and capnography³. Following successful LMA insertion, anesthesia was maintained with 2% sevoflurane and an equal mixture of O₂–N₂O (2 L/min). Mean arterial pressure (MAP), systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR) were recorded before induction (Tb), 1 minute after induction (T0), after successful LMA insertion (T1), and 3 (T2), 5 (T3), and 10 (T4) minutes after successful LMA insertion. I-gel LMA insertion conditions were evaluated by the degree of jaw relaxation using Young's Criteria¹⁰, while the overall insertion conditions were assessed using the Modified Scheme of Lund and Stovener¹⁰. The number of attempts, apneic time (time between the last spontaneous breath after induction and the resumption of spontaneous breathing), induction time (time from the start of induction to loss of consciousness), and the number of patients who received an additional bolus of propofol were recorded. If any of the reactions listed below occurred during the first attempt at I-gel insertion, a further bolus of 0.5 mg/kg of propofol was administered.

Criteria for assessment of laryngeal mask airway insertion conditions¹⁰

1. Jaw relaxation
 - Good: relaxed with no muscle tone
 - Incomplete: moderately relaxed with some muscle tone
 - Poor: poorly relaxed with full muscle tone
2. Patient response
 - 2.1 Coughing and gagging
 - None
 - Mild: one or two coughs
 - Moderate: three or more coughs
 - Severe: bucking
 - 2.2 Patient movement
 - None
 - Mild: transient or minimal
 - Moderate: lasted more than a few seconds but resolved within 20 seconds
 - Severe: sustained or needed propofol to allow LMA insertion

2.3 Laryngospasm

- None
 - Partial: stridor present, use of accessory muscles of respiration
 - Complete: paradoxical chest and abdominal movements, ventilation not possible
- Overall insertion conditions
- Excellent: no gagging, coughing, movement, or laryngospasm
 - Good: insertion resulting in mild to moderate coughing, gagging, or movement, with no laryngospasm
 - Poor: insertion possible but resulting in moderate to severe coughing, gagging, or patient movement, with no laryngospasm
 - Unacceptable: severe coughing, severe movement or laryngospasm

If hypotension occurred (defined as decrease in MAP of more than 20% from baseline), 6 mg of ephedrine (if HR < 60 bpm) or 4 µg of norepinephrine (if HR > 60 bpm) was administered. For patients with isolated bradycardia (HR < 50 bpm), 0.6 mg of atropine was given. In the event of laryngospasm, propofol 0.25–0.5 mg/kg¹¹ was administered;

if not relieved, 0.1–0.2 mg/kg of succinylcholine was subsequently given¹². Patients were excluded from the study if general anesthesia was maintained with an endotracheal tube, life threatening complications occurred, or an additional bolus of propofol was required more than once.

Data analysis was performed using Stata version 13 software (StataCorp, College Station, TX, USA). Descriptive statistics, including frequency and percentage, were used for categorical variables. Data distribution of continuous variables was examined using the Shapiro-Wilk test. The mean and standard deviation (SD) or the median (interquartile range [IQR]) was used for continuous variables. To compare proportions, the Chi-square test and Fisher's exact test were applied. The independent t-test and the Mann-Whitney U test were used to compare continuous variables between two groups as appropriate. Intergroup comparison of hemodynamic parameters at various time points were analyzed using linear mixed model, while intragroup comparison using linear mixed model followed by post hoc pairwise comparison with Bonferroni correction. Results were reported as beta coefficient (b) with 95% confidence intervals (95% CIs). A p-value < 0.05 was considered statistically significant.

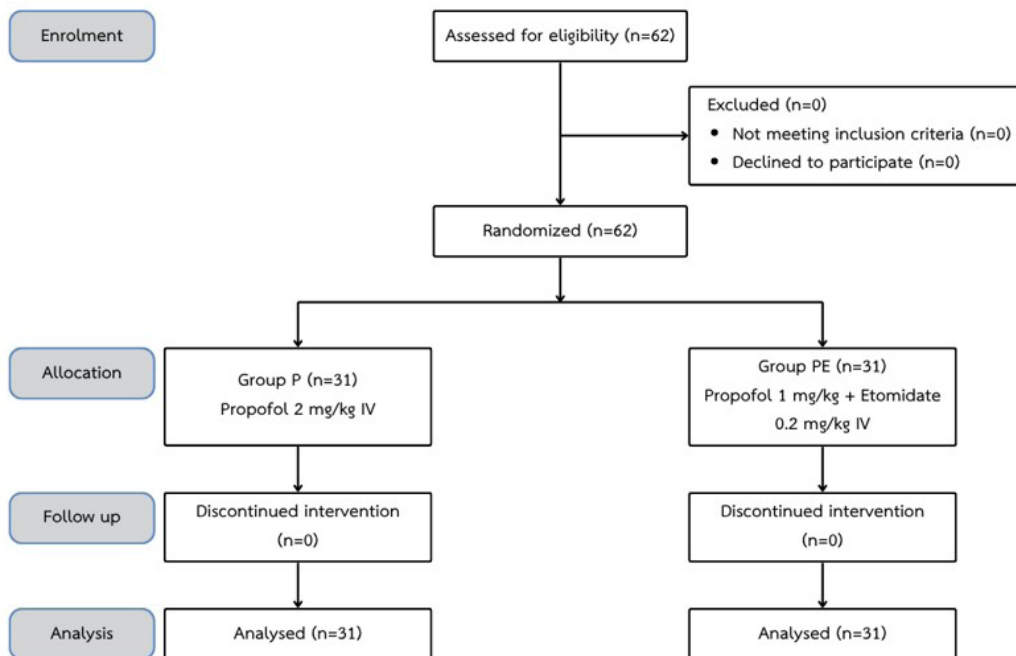


Figure 1 CONSORT flow diagram

Results

In this study, 62 patients from the General Surgery, Gynecology and Orthopedic departments were enrolled. There were no significant differences in demographic data and mean MAP, SBP, DBP, and HR before induction between the two groups (Table 1).

Mean MAP, SBP, and DBP decreased significantly from baseline at different time points in both groups, but there

were no significant differences between the two groups. HR at different time points decreased significantly from baseline at 10 minutes in group P, whereas there was a significant difference from baseline at 3, 5 and 10 minutes after LMA insertion in group PE. However, there were no significant differences between the two groups (Table 2).

Table 1 Baseline demographic and hemodynamic parameters

Parameter	Group P (n = 31)	Group PE (n = 31)	p-value
Age (yr), median (IQR)	46 (37-55)	46 (37-55)	0.994
Gender, n (%)			0.799
Male	17 (54.84%)	16 (51.61%)	
Female	14 (45.16%)	15 (48.39%)	
Weight (kg), mean $\pm$ SD	59.71 $\pm$ 10.74	59.74 $\pm$ 9.14	0.999
Height (cm), mean $\pm$ SD	164.32 $\pm$ 10.30	161.68 $\pm$ 8.81	0.282
BMI (kg / m ²), median (IQR)	21.40 (19.98-24.71)	23.82 (20.5-24.67)	0.324
ASA physical status, n (%)			0.442
I	16 (51.61%)	19 (61.29%)	
II	15 (48.39%)	12 (38.71%)	
Mallampati score, n (%)			0.799
I	15 (48.39%)	16 (51.61%)	
II	16 (51.61%)	15 (48.39%)	
Department, n (%)			0.960
General Surgery	14 (45.16%)	15 (48.39%)	
Gynecology	6 (19.35%)	6 (19.35%)	
Orthopedic	11 (35.48%)	10 (30.26%)	
MAP before induction (mmHg), mean $\pm$ SD	100.90 $\pm$ 9.13	98.32 $\pm$ 10.65	0.301
SBP before induction (mmHg), mean $\pm$ SD	137.03 $\pm$ 11.6	133.35 $\pm$ 13.90	0.255
DBP before induction (mmHg), mean $\pm$ SD	82.48 $\pm$ 9.07	80.61 $\pm$ 10.57	0.458
HR before induction (bpm), mean $\pm$ SD	72.48 $\pm$ 13.54	74.52 $\pm$ 13.72	0.559

Table 2 Comparison of hemodynamic changes from baseline during I-gel insertion between two groups

Parameter	Time vs Tb	Group P (n = 31) β (95% CI)	p -value ¹	Group PE (n = 31) β (95% CI)	p -value ¹	p -value ²
MAP (mmHg)	T0	-19.387 (-24.396, -14.379)	<0.001	-18.548 (-23.557, -13.540)	<0.001	0.816
	T1	-13.322 (-18.331, -8.314)	<0.001	-14.806 (-19.815, -9.798)	<0.001	0.681
	T2	-17.322 (-22.331, -12.314)	<0.001	-14.000 (-19.009, -8.992)	<0.001	0.358
	T3	-16.549 (-21.557, -11.540)	<0.001	-14.548 (-19.557, -9.540)	<0.001	0.580
	T4	-18.903 (-23.911, -13.895)	<0.001	-13.226 (-18.234, -8.217)	<0.001	0.116
SBP (mmHg)	T0	-25.742 (-32.126, -19.358)	<0.001	-25.065 (-31.448, -18.681)	<0.001	0.883
	T1	-18.968 (-25.351, -12.583)	<0.001	-21.161 (-27.545, -14.777)	<0.001	0.634
	T2	-23.613 (-29.997, -17.229)	<0.001	-19.194 (-25.577, -12.810)	<0.001	0.337
	T3	-23.065 (-29.449, -16.681)	<0.001	-19.258 (-25.642, -12.874)	<0.001	0.409
	T4	-25.129 (-31.513, -18.745)	<0.001	-18.742 (-25.126, -12.358)	<0.001	0.166
DBP (mmHg)	T0	-15.484 (-20.130, -10.838)	<0.001	-15.645 (-20.291, -10.999)	<0.001	0.962
	T1	-9.419 (-14.065, -4.774)	<0.001	-13.581 (-18.226, -8.935)	<0.001	0.214
	T2	-13.774 (-18.420, -9.128)	<0.001	-11.290 (-15.936, -6.645)	<0.001	0.459
	T3	-13.710 (-18.355, -9.064)	<0.001	-12.903 (-17.549, -8.258)	<0.001	0.810
	T4	-12.935 (-17.581, -8.290)	<0.001	-10.290 (-14.936, -5.645)	<0.001	0.430
HR (bpm)	T0	-0.968 (-4.949, 3.014)	0.634	-3.419 (-7.401, 0.562)	0.092	0.393
	T1	-0.258 (-4.240, 3.723)	0.899	-3.258 (-7.240, 0.724)	0.109	0.296
	T2	-0.516 (-4.498, 3.466)	0.799	-5.000 (-8.982, -1.018)	0.014	0.119
	T3	-3.710 (-7.691, 0.272)	0.068	-5.645 (-9.627, -1.663)	0.005	0.501
	T4	-4.226 (-8.208, -0.244)	0.038	-8.032 (-12.014, -4.051)	<0.001	0.185

p -value¹ = comparison within each group versus baseline (Tb)

p -value² = comparison between group P and Group PE

β = beta coefficient

Tb = before induction (baseline)

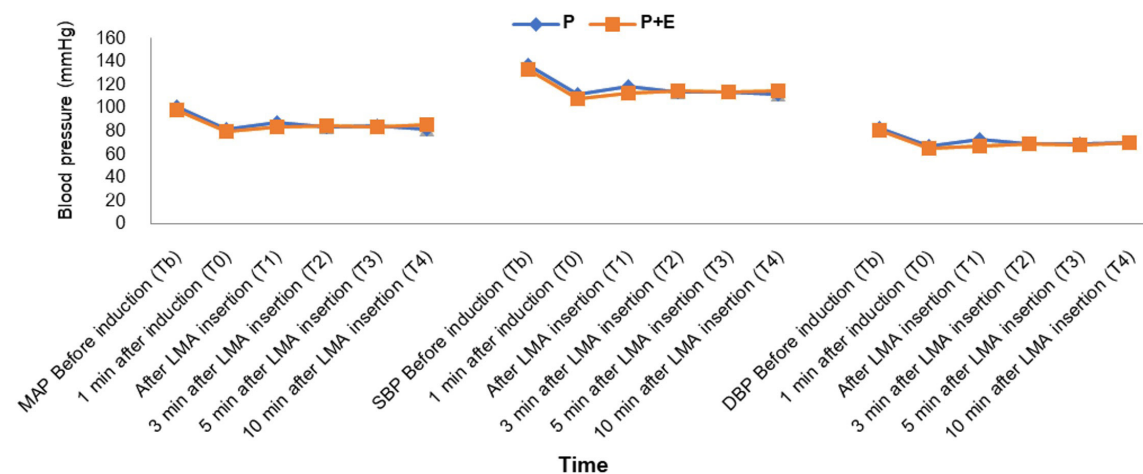
T0 = 1 minute after induction

T1 = after successful LMA insertion

T2 = 3 min after LMA insertion

T3 = 5 min after LMA insertion

T4 = 10 min after LMA insertion

**Figure 2** Comparison of MAP, SBP, and DBP at various time points between the two groups

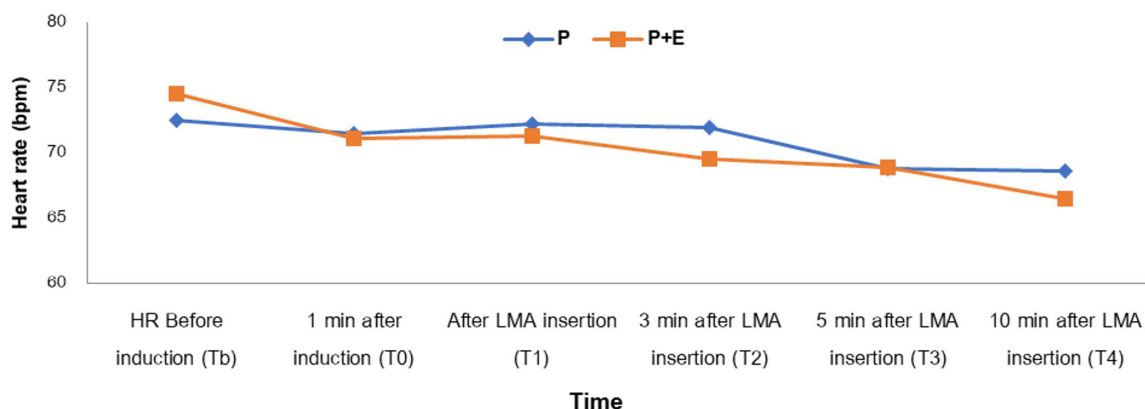


Figure 3 Comparison of HR at various time points between the two groups

For I-gel LMA insertion conditions, jaw relaxation was good in 74.19% of patients in group P and 61.29% in group PE; however, this difference was not statistically significant ($p=0.277$). Regarding patient response during LMA insertion, there were no statistically significant differences between the two groups for coughing and gagging or patient movement, although clinically, the incidence of no coughing was higher in group P. No laryngospasm was observed in either group. Overall LMA insertion conditions were rated as excellent in 80.65% of patients in group P and 74.19% in group PE

($p=0.785$). First-attempt success rates were 83.87% and 90.32% in groups P and PE, respectively ($p=0.307$) (Table 3). The number of patients who experienced hypotension (MAP dropped more than 20% from baseline) was 80.65% in group P and 67.74% in group PE ($p=0.246$). The total amounts of vasopressor and atropine administered were not significantly different between groups. The incidence of nausea and vomiting was approximately the same between groups (Table 4). None of patients experienced postoperative complications within 24 hours.

Table 3 LMA insertion conditions and number of insertion attempts

Parameter	Group P (n = 31)	Group PE (n = 31)	p-value
Jaw relaxation, n (%)			0.277
Good	23 (74.19%)	19 (61.29%)	
Incomplete	8 (25.81%)	12 (38.71%)	
Poor	0 (0.00%)	0 (0.00%)	
Gagging / coughing, n (%)			0.315
None	28 (90.32%)	24 (77.42%)	
Mild	2 (6.45%)	6 (19.35%)	
Moderate	1 (3.23%)	1 (3.23%)	
Severe	0 (0.00%)	0 (0.00%)	
Patient movement, n (%)			0.788
None	26 (83.87%)	26 (83.87%)	
Mild	4 (12.90%)	3 (9.68%)	
Moderate	1 (3.23%)	2 (6.45%)	
Severe	0 (0.00%)	0 (0.00%)	
Laryngospasm, n (%)			1.000
None	31 (100%)	31 (100%)	
Partial	0 (0.00%)	0 (0.00%)	
Complete	0 (0.00%)	0 (0.00%)	

Table 3 Continued

Parameter	Group P (n = 31)	Group PE (n = 31)	p-value
Overall insertion conditions, n (%)			0.785
Excellent	25 (80.65%)	23 (74.20%)	
Good	4 (12.90%)	6 (19.35%)	
Poor	2 (6.45%)	2 (6.45%)	
Unacceptable	0 (0.00%)	0 (0.00%)	
Number of attempts, n (%)			0.307
1	26 (83.87%)	28 (90.32%)	
2	5 (16.13%)	2 (6.45%)	
3	0 (0.00%)	1 (3.23%)	

Table 4 Incidence of hypotension, nausea and vomiting, vasopressor and atropine consumption

Parameter	Group P (n = 31)	Group PE (n = 31)	p-value
Hypotension, n (%)	25 (80.65)	21 (67.74)	0.246
Ephedrine (mg), median (IQR)	12 (6-18)	12 (9-18)	0.553
Norepinephrine (ug), mean $\pm$ SD	9.78 $\pm$ 3.53	10.80 $\pm$ 6.27	0.672
Atropine, n (%)	4 (12.90%)	2 (6.45%)	0.390
Nausea and vomiting, n (%)	0 (0.00%)	1 (3.23%)	0.313

Additionally, there were no significant differences in induction time (time from the start of induction until loss of consciousness), LMA insertion time (time from mouth opening until successful LMA insertion), apneic time (time

between the last spontaneous breath after induction and the resumption of spontaneous breathing) and additional propofol requirement (Table 5).

Table 5 Induction time, insertion time, apneic time and additional propofol requirement

Parameter	Group P (n = 31)	Group PE (n = 31)	p-value
Induction time (sec), median (IQR)	40 (35-46)	38 (35-43)	0.709
Insertion time (sec), median (IQR)	16 (12-20)	14 (12-22)	0.882
Apneic time (min), median (IQR)	2.43 (1.19-6.01)	1.79 (0.71-4.73)	0.132
Additional propofol requirement, n (%)	5 (16.13%)	6 (19.35%)	0.740

Discussion

LMA insertion requires adequate jaw relaxation and prevention of patient reactions to LMA insertion, such as movement and laryngospasm¹. Propofol is the most popular agent for LMA insertion due to its ability to obtund upper airway reflexes, but a dose of 2–3 mg/kg commonly results in hypotension and prolonged apnea⁵. Kanazawa et al.¹³ observed no significant differences among three propofol dosages (2, 2.5, and 3 mg/kg) in responses to LMA insertion. Previous studies demonstrated that fentanyl 1 μ g/kg pretreatment significantly reduced propofol requirements for LMA insertion¹⁴, caused less hypotension and bradycardia, and resulted in shorter apneic time than fentanyl 2 μ g/kg, while mouth opening and LMA insertion conditions were not different^{15,16}. Etomidate is an intravenous agent that is

suitable for patients with cardiovascular disease⁷. It can be used in combination with propofol for induction^{3,4,17-19}. Gade and Reddy¹⁷ evaluated hemodynamic changes after LMA insertion using the same etomidate dose with different doses of propofol. They found that etomidate 0.2 mg/kg combined with propofol 0.5 or 1 mg/kg resulted in better hemodynamic stability after LMA insertion than propofol 1.5 mg/kg alone, without a significant difference in insertion time. Accordingly, propofol 2 mg/kg and etomidate 0.2 mg/kg combined with propofol 1mg/kg were selected for this study.

The results of this study showed no significant difference in hemodynamic stability between the combination of propofol 1 mg/kg and etomidate 0.2 mg/kg and propofol 2 mg/kg after induction for I-gel LMA insertion. Mean

MAP, SBP, and DBP decreased significantly from baseline at all time points; however, no significant differences were observed between groups P and PE. Similarly, Liu et al.¹⁸ studied the efficacy and safety of ciprofol, propofol, a propofol-etomidate mixture, or a ciprofol-etomidate mixture in patients undergoing painless gastroscopy. In their study, group P received 200 mg of propofol, while group PE received a 1:1 mixture of propofol (100 mg in 10 mL) and etomidate (20 mg in 10 mL). They found no statistically significant differences in SBP, DBP, or HR at time points T0 (before induction), T1 (first minute after induction), and T2 (end of the examination) among the four groups. SBP and DBP in all four groups were significantly decreased at T1 and T2 compared with T0. This finding is likely attributed to reduced vascular tone and peripheral vasodilation following drug administration, leading to a decline in blood pressure. In our study, heart rate in group P decreased significantly compared with baseline at time point T4. In group PE, there were significant decreases from baseline at time points T2, T3, and T4; however, no significant differences were observed between the two groups. This may be related to the administration of an additional bolus of propofol or norepinephrine for the treatment of hypotension. Nevertheless, the heart rate changes observed were not clinically harmful.

In contrast to our study, Hosseinzadeh et al.³ studied hemodynamic changes following anesthesia induction and LMA insertion using propofol 2.5 mg/kg IV, etomidate 0.3 mg/kg IV, and a combination of propofol 1 mg/kg plus etomidate 0.2 mg/kg IV. They reported a significantly greater decrease in MAP, SBP, DBP, and HR at all stages of anesthesia after induction in the propofol group compared with the propofol + etomidate group. This finding is in accordance with the results of Jamwal et al.⁴ who evaluated hemodynamic changes during ProSeal LMA insertion using propofol, etomidate, and a propofol + etomidate admixture in patients undergoing laparoscopic cholecystectomy. SBP, DBP and MAP were reported to be lower in the propofol group but more stable in other two groups. A brief episode of increased blood pressure occurred after LMA insertion in the etomidate group, suggesting that the combination of etomidate and propofol provided greater hemodynamics stability compared with etomidate or propofol used alone. The difference between these studies and ours could be attributed to the higher dose of propofol (2.5 mg/kg) used in their study. Additionally, Viburajah and Selvaraj¹⁹ evaluated the effects of propofol, etomidate, and a combination of propofol and etomidate on the hemodynamic response to induction and endotracheal intubation and reported that a combination of propofol 1 mg/kg and etomidate 0.2 mg/kg was associated with greater hemodynamic stability compared with propofol 2 mg/kg, which differed from our findings. This difference may be related to the lower mean age of participants in their study compared with ours. Age differences may affect propofol requirements²⁰.

In our study, propofol provided slightly better jaw relaxation than the combination of propofol and etomidate. More patients in group PE exhibited gagging and coughing responses to LMA insertion than those in group P. This could account for the reduced propofol dose and less airway suppression by etomidate in group PE. However, these differences were not statistically significant. Head or limb movement was similar between two groups. Overall LMA insertion conditions and first-attempt success rates

were comparable between the two groups. However, there is a lack of previous studies comparing LMA insertion conditions between propofol alone and propofol combined with etomidate, as most prior studies mainly focused on hemodynamic stability and did not comprehensively evaluate LMA insertion conditions as performed in the present study. Dutt et al.¹⁵ compared insertion conditions for the classic LMA using propofol at a dose of 2.5 mg/kg, with fentanyl 1 (F₁) and 2 µg/kg (F₂) administered 3 minutes prior to LMA insertion. They found no statistically significant difference in insertion conditions between the two groups. The incidence of full mouth opening and gagging/coughing in the F1 and F2 groups from their study was comparable to that of good jaw relaxation and gagging/coughing observed in group P in our study, which was better than group PE, although the difference was not significant. First-attempt success rate and head/limb movement in their F1 and F2 groups were nearly the same as those in our P and PE groups. These indicated comparable efficacy of propofol 2 mg/kg with fentanyl 1 µg/kg versus propofol 2.5 mg/kg with fentanyl 1-2 µg/kg for LMA insertion conditions.

A shorter apneic time was observed in group PE compared with group P; however, the difference was not significant and may be associated with the reduced dose of propofol and minimal ventilatory effect of etomidate⁷.

The incidence of postoperative nausea and vomiting in both groups was approximately the same, which may be due to the antiemetic effect of propofol³.

The strengths of our study include its randomized, double-blind, controlled design, which was intended to minimize selection bias and ensure that the baseline characteristics of both groups were comparable. We also had clear objectives and well-defined assessment tools. The results have implications for clinical anesthesia practice. However, this study had some limitations. First, we did not use bispectral index monitoring (BIS) to evaluate the depth of anesthesia and guide the appropriate dosage of anesthetic drugs, which might have affected hemodynamic parameters. Second, additional boluses of propofol administered in response to patient reactions during LMA insertion might have affected blood pressure, although the number of patients requiring additional propofol was nearly the same in the two groups. Third, this study was conducted in healthy adult patients; therefore, outcomes in patients with cardiovascular disease or in elderly patients may differ. Finally, this study used I-gel LMA, other LMA type might yield different results.

Conclusion

A combination of propofol 1 mg/kg and etomidate 0.2 mg/kg was not superior to propofol 2 mg/kg for induction in terms of hemodynamic stability. Both regimens resulted in significant decreases in MAP, SBP, and DBP from baseline. Propofol provided slightly better jaw relaxation and fewer patient responses to I-gel LMA insertion than the combination of propofol and etomidate; however, these differences were not statistically significant. Overall insertion conditions and first-attempt success rates were not significantly different between the two groups.

Ethical Approval

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Human Research Ethics Committee of

Kumphawapi Hospital (protocol code KPEC 23/2568; approval date: 2 May 2025). Informed consent was obtained from all participants or their legal representatives.

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บทความวิจัย

ผลของการนำสลบด้วย propofol ร่วมกับ etomidate เปรียบเทียบกับ propofol เพียงอย่างเดียว ต่อสถานะในการใส่หน้ากากครอบกล่องเสียงชนิด I-gel

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บทคัดย่อ

Propofol เป็นยาที่นิยมใช้ในการนำสลบเพื่อการใส่หน้ากากครอบกล่องเสียงแต่ก็มีผลทำให้ระบบไหลเวียนโลหิตไม่คงที่และมีภาวะแทรกซ้อนของระบบหัวใจและหลอดเลือด มีการศึกษาการใช้ยาระงับความรู้สึกทางหลอดเลือดดำหลายชนิดร่วมกับ propofol เพื่อลดภาวะแทรกซ้อนดังกล่าว การศึกษาไปข้างหน้าแบบสุ่มที่มีกลุ่มควบคุมและปกปิดนี้มีวัตถุประสงค์เพื่อเปรียบเทียบผลของการนำสลบในการใส่ I-gel LMA ด้วย propofol ร่วมกับ etomidate และ propofol เพียงอย่างเดียว ต่อระบบไหลเวียนโลหิต สถานะในการใส่ LMA อัตราความสำเร็จในการใส่ LMA ครั้งแรก มีผู้เข้าร่วมวิจัยจำนวน 62 คน อายุ 18-64 ปี ASA physical status I-II ที่มาผ่าตัดแบบไม่เร่งด่วนภายใต้การระงับความรู้สึกแบบทั่วร่างกายที่โรงพยาบาลกุมภวาปี จังหวัดอุดรธานี ประเทศไทย ระหว่างเดือนพฤษภาคม 2568 ถึง สิงหาคม 2568 ผู้ป่วยถูกแบ่งโดยการสุ่มให้อยู่ในกลุ่ม propofol (P) 31 คน ซึ่งจะได้รับ propofol 2 มก/กก และกลุ่ม propofol ร่วมกับ etomidate (PE) จะได้รับ propofol 1 มก/กก ร่วมกับ etomidate 0.2 มก/กก ในการนำสลบ ประเมินและบันทึกค่าทางระบบไหลเวียนโลหิตก่อนการนำสลบ 1 นาที หลังนำสลบ หลังใส่ LMA สำเร็จทันที 3 5 และ 10 นาที หลังใส่ LMA สำเร็จ สถานะในการใส่ LMA และอัตราความสำเร็จในการใส่ LMA ครั้งแรก ผลการศึกษาพบว่าไม่มีความแตกต่างอย่างมีนัยสำคัญของ ความดันโลหิตเฉื่อย ความดันโลหิตตัวบนและตัวล่าง อัตราการเต้นหัวใจ ของทั้ง 2 กลุ่ม ทุกช่วงเวลา ($p>0.050$) การหย่อนของขากรรไกร กลุ่ม P อยู่ในระดับดี 23/31 ราย (ร้อยละ 74.19) และ 19/31 ราย (ร้อยละ 61.29) ในกลุ่ม PE ($p=0.277$) สถานะโดยรวมขณะใส่หน้ากากครอบกล่องเสียงทั้งสองกลุ่มไม่มีความแตกต่างกัน ($p=0.785$) อัตราความสำเร็จในการใส่ LMA ครั้งแรกร้อยละ 83.37 และ 90.32 ในกลุ่ม P และ PE ตามลำดับ ($p=0.307$) โดยสรุป ผลของการนำสลบด้วย propofol 1 มก/กก ร่วมกับ etomidate 0.2 มก/กก และ propofol 2 มก/กก ต่อระบบไหลเวียนโลหิต การหย่อนของขากรรไกร สถานะการใส่หน้ากากครอบกล่องเสียง และอัตราความสำเร็จในการใส่หน้ากากครอบกล่องเสียงสำเร็จในครั้งแรกไม่มีความแตกต่างกันอย่างมีนัยสำคัญ

ORIGINAL ARTICLE

Prevalence of Bone Metastases Detected by Bone Scan in Patients with Hepatocellular Carcinoma

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KEYWORDS

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ABSTRACT

Early-stage hepatocellular carcinoma (HCC) is curable by liver transplantation (LTx). However, donor scarcity necessitates a meticulous selection via Milan criteria. Although updated guidelines omit routine bone scans (BS) for staging, most Thai tertiary care centers still standardly perform them for LTx candidates with HCC. The aim of this study was to determine the prevalence of bone metastasis (BM) detected by BS among patients with HCC in northeastern Thailand and to assess the potential role of BS in the preoperative evaluation for LTx. This was a retrospective cross-sectional descriptive study of BS images of 101 patients with HCC who were referred to the Division of Nuclear Medicine, Srinagarind Hospital, Faculty of Medicine, Khon Kaen University. The prevalence of BS positivity and its potential associated factors were analyzed. A total of 16 patients had a positive BS (15.8%; 95% CI: 8.6–23.1) across multiple Barcelona Clinic Liver Cancer (BCLC) stages, including one patient in the very early stage (14.3%; 95% CI: 1.6–62.8). Among the 43 patients meeting the Milan criteria for LTx, three were found with positive BS (7.0%; 95% CI: 2.2–20.0). Bivariate analyses to determine the association between BS positivity and BCLC stage, Milan criteria, macrovascular invasion, largest tumor size, lymph node metastasis, and alpha-fetoprotein (AFP) level were performed, and tumors beyond the Milan criteria (crude OR 3.85; 95% CI: 1.02–14.5; $p=0.046$), the presence of macrovascular invasion (crude OR 3.05; 95% CI: 1.02–14.5; $p=0.046$), and N1 stage (crude OR 9.11; 95% CI: 1.81–45.8; $p=0.007$) demonstrated a statistically significant association with BS positivity. However, upon further evaluation using multivariable logistic regression to adjust for potential confounders, no factors remained statistically significant in association with positive BS. These findings suggest that BS may still have a role in the preoperative evaluation of patients with HCC being considered for LTx.

Introduction

Hepatocellular carcinoma (HCC) is the most common type of primary liver cancer, accounting for 80% of all cases¹. It is also the sixth most common cancer worldwide and the third leading cause of cancer-related death². In Thailand, HCC has the highest incidence, accounting for 15.2% of all cancers, and is also the leading cause of cancer-related death, with a mortality rate of 22.8%³. Significant risk factors for HCC include chronic viral hepatitis (hepatitis B virus [HBV] and hepatitis C virus [HCV]) infection, alcoholic liver disease, non-alcoholic steatohepatitis (NASH)/non-alcoholic fatty liver disease (NAFLD), and aflatoxin ingestion⁴.

The management strategy for HCC is dictated by the stage of the disease, for which the Barcelona Clinic Liver Cancer (BCLC) staging system⁵ is widely accepted. For patients with early-stage disease, liver transplantation (LTx) offers a definitive curative option, as it addresses not only the malignancy, but also the underlying liver dysfunction. However, the scarcity of the organ donors necessitates a

meticulous patient selection process. The Milan criteria⁶—defined as unresectable HCC with limited tumor burden (a single tumor ≤ 5 cm or up to three tumors with none exceeding 3 cm and no imaging evidence of macrovascular invasion or extrahepatic spread)—are one of the most widely used standard criteria for selecting appropriate candidates and ensuring favorable post-LTx outcomes.

Previously, before patients were included on the LTx waiting list, international guidelines for LTx, such as those of the European Association for the Study of the Liver (EASL)⁷ and the American Association for the Study of Liver Diseases (AASLD)⁸ recommended comprehensive staging to exclude extrahepatic metastatic disease. This evaluation typically included the computed tomography (CT) scans of the chest to assess pulmonary metastasis and bone scans (BS) to detect bone metastasis (BM). However, recent updates to both EASL⁹ and AASLD¹⁰ clinical practice guidelines for the management of HCC no longer recommend BS to be routinely performed for staging. Despite this shift, there is

no clear statement on whether BS should be omitted from the preoperative work-up for LTx candidates. While BS is widely available and affordable for most patients, its diagnostic sensitivity is reportedly limited for the predominantly osteolytic lesions characteristic of HCC^{11–14}. Nevertheless, routine BS remains the standard practice for all LTx candidates with HCC at our institution and in the majority of tertiary care centers in Thailand.

The prevalence of BM in patients with HCC ranges from 2% up to 20% in the literature^{12,13,15–29}. This wide variation suggests that the risk profile may vary across different patient populations. Therefore, this study was undertaken to determine the prevalence of BM detected by BS among patients with HCC in northeastern Thailand and to assess the potential role of BS in the preoperative evaluation for LTx.

Materials and Methods

Patient Characteristics

The authors retrospectively reviewed the medical records of all patients aged 18 years or older diagnosed with HCC who were referred for BS to the Division of Nuclear Medicine, Department of Radiology, Faculty of Medicine, Khon Kaen University, between January 1, 2013, and December 31, 2020. The inclusion criteria comprised patients with HCC whose diagnosis was confirmed by radiological imaging (CT or magnetic resonance imaging [MRI]), with or without elevated alpha-fetoprotein (AFP) levels, who underwent BS either prior to diagnosis or within 12–16 weeks post-diagnosis. Patients were excluded from the study if they were diagnosed with other concomitant malignancies or if their medical or radiological records required for inclusion were incomplete. Demographic characteristics were collected from medical records, including age, sex, etiology, Child–Turcotte–Pugh (CTP) score, AFP levels, and Eastern Cooperative Oncology Group (ECOG) performance status. Afterward, patients were classified according to the BCLC staging system based on tumor size and number, macrovascular invasion, nodal involvement, and metastatic spread which were individually assessed by a diagnostic radiologist using the available imaging modalities.

Image Acquisition

Whole-body BS was performed approximately 3 hours after the intravenous injection of 555–740 megabecquerels (MBq) (15–20 millicuries [mCi]) of technetium-99m methylene diphosphonate (^{99m}Tc-MDP). Anterior and posterior planar images were obtained using dual-headed (Vertex V60 EPIC HP [ADAC, CA, USA], Discovery NM/CT 670 [GE Healthcare, IL, USA], Discovery MN 830 [GE Healthcare, IL, USA] or Symbia Intevo 2 [Siemens AG, Berlin and Munich, Germany]) or single-headed (Genesys [ADAC, CA, USA]) gamma cameras. In cases where planar images were inconclusive, single-photon emission computed tomography with CT (SPECT/CT) was performed using hybrid systems (Discovery NM/CT 670 [GE Healthcare, IL, USA] or Symbia Intevo 2 [Siemens AG, Berlin and Munich, Germany]) to further characterize the lesions.

Image Interpretation

Two nuclear medicine physicians, blinded to the patients' identification, clinical history, laboratory results, and other imaging studies, independently interpreted the BS. Discrepancies were resolved by a third reader by

consensus. BS were categorized as positive, negative or equivocal. A positive planar scan was defined by the presence of solitary or multiple focal lesions, diffuse uptake (superscan), or photon-deficient lesions, after excluding benign etiologies such as bone fractures, infections, or degenerative changes. For SPECT/CT images, positivity was defined as increased or decreased radiotracer uptake corresponding to osteolytic, osteoblastic or mixed osteolytic/osteoblastic lesions on the CT portion. Equivocal results that could not be definitively classified were grouped with negative scans for the final analysis.

Statistical Analysis

Data analysis was performed using Stata version 13.1 (StataCorp LLC, TX, USA). Demographic characteristics were summarized using descriptive statistics; continuous variables were expressed as mean ± standard deviation (SD) for normally distributed data or median and range for non-normally distributed data, while categorical variables were presented as numbers and percentages. The prevalence of positive BS was calculated and stratified by BCLC stage, Milan criteria eligibility, and the presence of macrovascular invasion. Analyses were conducted separately for planar studies and studies combined with SPECT/CT (if available). Results were reported as numbers, percentages, and 95% confidence intervals (95% CI). A sensitivity analysis was conducted to evaluate the impact of BS with equivocal results on prevalence estimates. Bivariate and multivariable logistic regression analyses were performed to calculate crude and adjusted odds ratios (ORs), respectively, to identify factors associated with BS positivity. Covariates included in the models were BCLC stage, Milan criteria status, presence of macrovascular invasion, tumor size, nodal metastasis, and AFP levels. A *p*-value of less than 0.05 was considered statistically significant.

Results

Patient Characteristics

128 patients initially met the inclusion criteria based on a retrospective review of medical records between January 1, 2013, and December 31, 2020. However, after excluding 10 patients with concomitant malignancies and 17 patients with incomplete medical or radiological records, a total of 101 patients were included in the final analysis.

As detailed in Table 1, the majority of the patients were male (84.2%) with a mean age of 56.5 years (range, 33–81 years). The predominant etiology for HCC was HBV and/or HCV infection, accounting for 88.1% of cases. Only eight patients (7.9%) had alcoholic cirrhosis as the sole risk factor. Most patients (98.1%) had preserved liver function (CTP score A or B), but two patients presented with CTP score C (classified as BCLC stage D).

AFP levels were available for 100 patients, with a median of 54.9 ng/mL and a wide range of 2.5–269,853.0 ng/mL. Using a cut-off of 20 ng/mL³⁰, 63.4% of patients had elevated AFP levels. Regarding staging using tumor–node–metastasis (TMN) system according to the eighth edition of the American Joint Committee on Cancer (AJCC) Cancer Staging Manual³¹, most patients were classified as TNM stage I (33.7%) or stage II (29.7%). Macrovascular invasion was present in 28.7% of patients. Prior to the inclusion of BS, 13 patients (12.9%) were radiologically identified as having extrahepatic spread, consisting of pulmonary

metastases in six patients and BM in seven patients. When classified by the BCLC staging system, the largest group was BCLC stage C (37.6%), followed by stage A (32.7%).

Table 1 Demographic characteristics of the study population

Characteristics	Total (n = 101) n (%)
Age at diagnosis, years, mean $\pm$ SD (range)	56.5 $\pm$ 8.5 (33–81)
Sex	
Male	85 (84.2)
Female	16 (15.8)
Etiology	
HBV alone	33 (32.6)
HCV alone	43 (42.6)
HBV+HCV	4 (4.0)
Others	17 (16.8)
- Alcohol alone	8 (7.9)
- Alcohol with HBV	3 (2.9)
- Alcohol with HCV	6 (5.9)
Not identified	4 (4.0)
ECOG score	
0	21 (20.8)
1	11 (10.9)
2	0 (0)
3	1 (1.0)
4	1 (1.0)
Not identified	67 (66.3)
CTP score	
A	54 (53.5)
B	45 (44.6)
C	2 (1.9)
AFP level, ng/ mL, median (range)	54.9 (2.5–269,853.0)
$\leq$ 20	36 (35.6)
>20	64 (63.4)
Not identified	1 (1.0)
T stage	
T1	35 (34.6)
- T1a	8 (7.9)
- T1b	27 (26.7)
T2	32 (31.7)
T3	5 (5.0)
T4	29 (28.7)
N stage	
N0	94 (93.1)
N1	7 (6.9)
M stage	
M0	88 (87.1)
M1	13 (12.9)

Table 1 Continued

Characteristics	Total (n = 101) n (%)
TNM stage	
Stage I	34 (33.7)
- Stage IA	8 (7.9)
- Stage IB	26 (25.8)
Stage II	30 (29.7)
Stage III	23 (22.7)
- Stage IIIA	4 (3.9)
- Stage IIIB	19 (18.8)
Stage IV	14 (13.9)
- Stage IVA	2 (2.0)
- Stage IVB	12 (11.9)
Number of hepatic nodules	
1	53 (52.5)
2–3	29 (28.7)
>3	19 (18.8)
The largest tumor size (cm)	
≤2	17 (16.8)
>2–5	50 (49.5)
>5	34 (33.7)
Macrovascular invasion	
No	72 (71.3)
Yes	29 (28.7)
BCLC staging system	
0	7 (6.9)
A	33 (32.7)
B	19 (18.8)
C	38 (37.6)
D	4 (4.0)

BS Findings

As shown in Table 2, among the 101 patients, seven had evidence of BM prior to BS; all of these patients were classified as BCLC stage C and were beyond the Milan criteria. BS further identified additional positive cases of BM, bringing the total number of patients with BM to 16. Notably, positive BS results were detected across all BCLC stages, including one patient (14.3%; 95% CI: 1.6–62.8) in the very early stage (BCLC 0).

In the analysis of planar images, six cases were interpreted as equivocal. A one-way sensitivity analysis was performed to compare the impact of classifying these equivocal results as negative versus positive. The estimated prevalence of BM was 15.8% (95% CI: 8.6–23.1) using the first method (negative) and 21.8% (95% CI: 13.6–29.9) using the second (positive); this difference was not statistically

significant. Furthermore, SPECT/CT was performed in only 28 cases. In the majority of these cases (22/28), SPECT/CT results were concordant with the planar interpretation. Of the six equivocal planar cases, only one was reclassified as positive following SPECT/CT. Consequently, the final data analysis treated equivocal planar scans as negative.

Based on this analysis, the prevalence of BM detected by BS in patients with HCC was 15.8% (16/101; 95% CI: 8.6–23.1). Among patients meeting the Milan criteria, the prevalence was 7.0% (3/43; 95% CI: 2.0–20.0).

Additionally, two patients exhibited false-negative BS results. Both had osteolytic lesions confirmed on CT scans prior to BS but showed no corresponding abnormal radiotracer uptake on the planar images (see Figures 1 and 2). This resulted in a false-negative rate of 2.4% (2/85) among patients with negative scans.

Table 2 Bone metastasis in patients with hepatocellular carcinoma based on bone scan results

Stage of hepatocellular carcinoma (before bone scan)	Total (n=101)	Bone metastasis detected before bone scan n (% , 95% CI)	Bone metastasis detected after bone scan n (% , 95% CI)
BCLC (all stages)	101	7 (6.9, 1.9–12.0)	16 (15.8, 8.6–23.1)
BCLC 0	7	0 (0)	1 (14.3, 1.6–62.8)
BCLC A	33	0 (0)	3 (9.1, 2.9–25.3)
BCLC B	19	0 (0)	2 (10.5, 2.5–35.1)
BCLC C	38	7 (18.4, 8.9–34.4)	10 (26.3, 14.6 - 42.8)
BCLC D	4	0 (0)	0 (0)
Within Milan criteria	43	0 (0)	3 (7.0, 2.2–20.0)
Beyond Milan criteria	58	7 (12.1, 5.8–23.5)	13 (22.4, 13.3–35.2)
No macrovascular invasion	72	3 (4.2, 1.3–12.4)	8 (11.1, 5.6–20.9)
Macrovascular invasion	29	4 (13.8, 5.1–32.1)	8 (27.6, 14.1–46.8)

Factors Associated with Positive BS

Both bivariate and multivariable logistic regression analyses were performed to identify factors associated with positive BS. The variables evaluated included BCLC stage, Milan criteria status, presence of macrovascular invasion, largest tumor diameter, lymph node metastasis (N stage), and AFP level, as shown in Table 3.

In the bivariate analysis, three factors demonstrated statistically significant associations with positive BS: tumors beyond the Milan criteria (crude OR 3.85; 95% CI: 1.02–14.5; $p=0.046$), presence of macrovascular invasion (crude OR 3.05; 95% CI: 1.02–9.13; $p=0.046$), and nodal metastasis (N1 stage) (crude OR 9.11; 95% CI: 1.81–45.8; $p=0.007$). However, upon further evaluation using multivariable logistic regression to adjust for potential confounders, no factors remained statistically significant in association with positive BS.

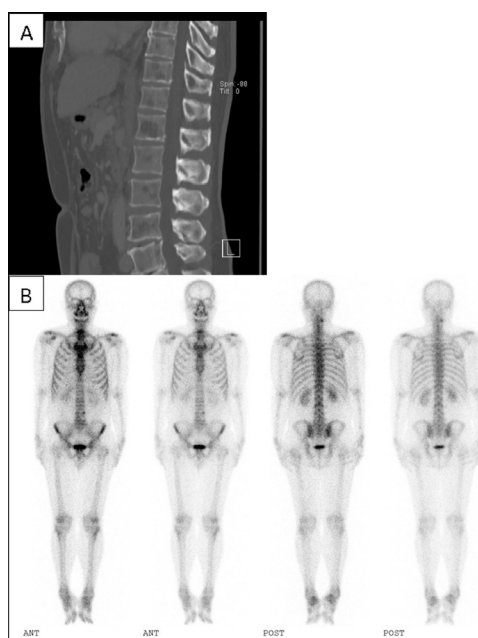


Figure 1 A 71-year-old male with HCC. CT scan images prior to the BS (A) revealed multiple osteolytic lesions along the lower thoracic and lumbar vertebrae, suggestive of BM, whereas the planar BS (B) was interpreted as negative, showing only degenerative changes at the cervical and lumbar vertebrae.



Figure 2 A 77-year-old male with HCC. CT scan images prior to the BS (A, B) revealed osteolytic lesions, suggestive of BM, with a pathologic fracture at the L1 vertebra. The planar BS (C) was interpreted as negative. The increased radiotracer uptake was considered to be due to an osteoporotic compression fracture rather than BM.

Table 3 Factors associated with bone metastasis in hepatocellular carcinoma detected by bone scan

Factors	No. of bone metastasis (n (%))	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
BCLC staging system					
0	1 (14.3)	1		1	
A	3 (9.1)	0.60 (0.53–6.80)	0.680	0.82 (0.03–19.3)	0.901
B	2 (10.5)	0.71 (0.54–9.27)	0.791	0.26 (0.004–15.3)	0.517
C	10 (26.3)	2.14 (0.23–20.1)	0.504	0.35 (0.005–22.8)	0.623
D	0 (0)	N/A		N/A	
Milan criteria					
Tumor within Milan criteria	3 (7.0)	1		1	
Tumor beyond Milan criteria	13 (22.4)	3.85 (1.02–14.5)*	0.046*	3.31 (0.18–61.7)	0.421
Macrovascular invasion					
No	72 (71.3)	1		1	
Yes	29 (28.7)	3.05 (1.02–9.13)*	0.046*	0.97 (0.11–8.52)	0.979
Largest tumor size					
≤2 cm	2 (11.8)	1		1	
>2–5 cm	3 (6.0)	0.48 (0.07–3.14)	0.443	0.52 (0.05–5.93)	0.602
>5 cm	11 (32.4)	3.59 (0.70–18.5)	0.127	2.88 (0.18–45.5)	0.454
N stage					
N0	94 (93.1)	1		1	
N1	7 (6.9)	9.11 (1.81–45.8)*	0.007*	3.83 (0.58–25.0)	0.162
AFP level (ng/mL)					
≤20	5 (13.9)	1		1	
>20	11 (17.2)	1.29 (0.41–4.05)	0.667	0.55 (0.13–2.36)	0.422
Not identified	0	N/A		N/A	N/A

Discussion

This study observed a prevalence of BM of 15.8% (16/101 patients), which is higher than the 4.42% reported by Huang et al.²³, who analyzed data from the Surveillance, Epidemiology, and End Results (SEER) Program³². However, our finding remains within the range of 2% to 20% range reported in other studies^{12,13,15–29}.

In the case of the two patients with CTP score C who were initially classified as BCLC stage D, recent updates to the BCLC staging system regarding treatment stage migration suggest that such patients may still be considered for LTx if their liver function improves.

A key characteristic of our study population is the high prevalence of viral hepatitis, with 88.1% of patients having HBV or HCV as the etiology of HCC. Yang et al.³³ reported that HBV infection in HCC patients is associated with greater disease severity, characterized by earlier onset (by approximately 10 years), higher rates of cirrhosis, elevated AFP levels, higher CA19-9 levels, increased microvascular invasion, and significantly lower neutrophil-to-lymphocyte ratios (NLR) and platelet-to-lymphocyte ratios (PLR) compared with non-HBV patients. This etiological difference may explain why our study observed a higher prevalence of BM compared with studies involving predominantly Western populations^{15,20–23}, where the prevalence is often less than 5%. In Western cohorts, HCC is more commonly associated with alcoholic cirrhosis, metabolic syndrome, and NASH³⁴. Conversely, our results align more closely with studies from Asian populations^{12,18,19,26,27}, where HBV/HCV prevalence is higher and BM rates range from 6.5% to 20%.

Crucially, this study identified positive BS in three patients (7.0%) who met the Milan criteria, which is comparable to the findings of Erhamamcı et al.³⁵, who reported BM in 5 of 46 LTx candidates (10.9%). Considering the increasing trend of BM detection noted by Huang et al.³⁶ and Fukutomi et al.¹⁸, our findings suggest that BS cannot yet be safely omitted from the screening protocol for HCC patients listed for LTx.

Regarding false-negative results, two patients (2.4% of the negative scan group) presented with osteolytic lesions on CT scans (one involving the lower thoracic and lumbar vertebrae and the other an L1 vertebra with a pathologic fracture) but had negative planar BS. This highlights a limitation of BS in detecting purely osteolytic lesions, consistent with Chen et al.²⁷, who reported a false-negative rate as high as 42.4% in patient-based analysis and 27.0% in lesion-based analysis.

Positive BS were observed across all BCLC stages, including the very early stage (BCLC 0). Although the highest number of positive cases was found in BCLC stage C (advanced stage), no positive cases were detected in BCLC stage D, likely due to the small sample size ($n=4$) in that group. Multivariable logistic regression analysis revealed that the adjusted odds ratio did not significantly increase with advancing disease stage. This indicates that BM can occur at any stage of HCC, with a prevalence of 14.3% in BCLC 0, 9.1% in BCLC A, and 10.5% in BCLC B in our study. These findings support the necessity of routine BS for all HCC patients.

Previous literature suggests that factors such as tumor size, macrovascular invasion, lymph node metastasis, and tumor markers (e.g., AFP) are associated with BM^{19,21,26,36,37}. Although the 2022 BCLC update⁵, Huang et al.³⁶, and He et

al.³⁷ emphasize the relationship between AFP levels, disease stage, and survival, our study did not find a statistically significant association between AFP levels and positive BS in either bivariate or multivariable analyses. This may be attributed to the non-normal distribution of AFP data in our study.

While bivariate analysis showed that presence of macrovascular invasion, nodal metastasis (N1), and tumor beyond the Milan criteria were associated with positive BS, these factors did not retain statistical significance in the multivariable analysis. This contrasts with the study by Hu et al.²², which identified N1 stage, ethnicity, sex, histological grade, and T stage as significant factors. The discrepancy may be due to the descriptive nature of our study, which was not powered to calculate the sample size required for robust risk factor analysis.

This study has several limitations. Due to its retrospective design, some data were incomplete; not all patients underwent additional SPECT/CT beyond planar BS, and ECOG performance status was unavailable for a portion of patients, which may have influenced the accuracy of BCLC staging. BM from HCC are predominantly osteolytic and may occasionally result in false-negative BS findings, although only two such cases were observed in this cohort. In addition, the relatively small sample size and retrospective patient selection may limit the generalizability of the findings. Finally, histopathological confirmation of bone lesions was not routinely available, and therefore positive BS findings were interpreted based on imaging and clinical correlation.

Conclusion

In this study, BM detected by BS were identified in 15.8% of patients with HCC and in 7.0% of those meeting the Milan criteria for LTx. Notably, BM were observed across multiple BCLC stages, including early-stage disease, and no significant predictors of positive BS were identified. These findings suggest that BS may still have a role in the preoperative evaluation of patients with HCC being considered for LTx. However, further studies with larger cohorts are warranted to better define its clinical value in this setting.

Ethical Approval

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Human Research Ethics Committee of Khon Kaen University (protocol code HE641433; approval date: 24 August 2021). Informed consent was obtained from all participants or their legal representatives.

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บทความวิจัย

ความชุกของการแพร่กระจายไปยังกระดูกที่ตรวจพบด้วยการสแกนกระดูกในผู้ป่วยมะเร็งตับปฐมภูมิ ชนิดเฮปาโตเซลล์ูลาร์คาร์ซิโนมา

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คำสำคัญ

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มะเร็งตับชนิดเฮปาโตเซลล์ูลาร์คาร์ซิโนมาในระยะเริ่มต้นนั้นสามารถรักษาให้หายขาดได้ด้วยการปลูกถ่ายตับ อย่างไรก็ตาม ความขาดแคลนผู้บริจาคอวัยวะทำให้จำเป็นต้องมีการบวนการคัดเลือกผู้ป่วยอย่างละเอียดถี่ถ้วนด้วยเกณฑ์มีลาน แต่ถึงแม้ว่าแนวทางแนวทางสำหรับการดูแลรักษามะเร็งตับชนิดนี้ฉบับล่าสุดได้ยกเลิกการแนะนำการสแกนกระดูกอย่างเป็นทางการก็จริงแต่ระยะของโรคไปแล้ว กระนั้นการสแกนกระดูกยังคงเป็นการส่งตรวจที่จำเป็นปฏิบัติกันอยู่สำหรับผู้ป่วยมะเร็งตับที่เป็นผู้รอรับการปลูกถ่ายตับในโรงพยาบาลระดับตติยภูมิส่วนใหญ่ในประเทศไทย วัตถุประสงค์ของการศึกษานี้คือเพื่อหาความชุกของการแพร่กระจายของมะเร็งไปยังกระดูกที่ตรวจพบจากการสแกนกระดูกในผู้ป่วยในภาคตะวันออกเฉียงเหนือของประเทศไทย เพื่อให้เข้าใจถึงบทบาทและความจำเป็นของการสแกนกระดูกในฐานะการตรวจประเมินก่อนการผ่าตัดปลูกถ่ายตับได้ดียิ่งขึ้น การศึกษานี้เป็นการศึกษาเชิงพรรณนาแบบตัดขวางย้อนหลังของภาพสแกนกระดูกในผู้ป่วยมะเร็งตับจำนวน 101 ราย ที่ถูกส่งมารับการตรวจสแกนกระดูก ณ หน่วยเวชศาสตร์นิวเคลียร์ โรงพยาบาลศรีนครินทร์ คณะแพทยศาสตร์ มหาวิทยาลัยขอนแก่น ผู้วิจัยได้วิเคราะห์ความชุกของการให้ผลเป็นบวกจากการสแกนกระดูกและปัจจัยที่อาจมีความเกี่ยวข้อง ผลการศึกษาพบผู้ป่วยที่มีผลสแกนกระดูกเป็นบวกจำนวน 16 ราย (ร้อยละ 15.8; 95% CI: 8.6–23.1) ซึ่งพบในทุกระยะตามระบบการแบ่งระยะโรคตามระบบบาร์เซโลนาคลินิก แม้ในระยะเริ่มแรกมาก (very early stage) ก็ยังพบผู้ป่วยที่มีผลบวก 1 ราย (ร้อยละ 14.3; 95% CI: 1.6–62.8) และในจำนวนผู้ป่วย 43 รายที่เข้าเกณฑ์มีลานสำหรับผู้รอรับการปลูกถ่ายตับ พบผู้ป่วยที่มีผลสแกนกระดูกเป็นบวก 3 ราย (ร้อยละ 7.0; 95% CI: 2.2–20.0) การวิเคราะห์หัตถ์แปรคู่เพื่อหาความสัมพันธ์ระหว่างผลบวกของการสแกนกระดูกกับระยะตามระบบบาร์เซโลนาคลินิก เกณฑ์มีลาน การลุกลามของมะเร็งเข้าสู่หลอดเลือด ขนาดก้อนมะเร็งที่ใหญ่ที่สุด การแพร่กระจายไปยังต่อมน้ำเหลือง และระดับของสารอัลฟา-ฟีโตโปรตีน พบว่า การมีก้อนมะเร็งเกินเกณฑ์มีลาน (crude OR 3.85; 95% CI: 1.02–14.5; $p=0.046$), การพบการลุกลามของมะเร็งเข้าสู่หลอดเลือด (crude OR 3.05; 95% CI: 1.02–14.5; $p=0.046$) และระยะลุกลามไปต่อมน้ำเหลือง (crude OR 9.11; 95% CI: 1.81–45.8; $p=0.007$) มีความสัมพันธ์กับผลบวกของการสแกนกระดูกอย่างมีนัยสำคัญทางสถิติ อย่างไรก็ตาม เมื่อประเมินเพิ่มเติมโดยใช้การถดถอยโลจิสติกพหุแปร เพื่อปรับแก้ปัจจัยกวนที่อาจเกิดขึ้น ไม่พบปัจจัยใดที่ยังคงมีความสัมพันธ์กับผลบวกของการสแกนกระดูกอย่างมีนัยสำคัญทางสถิติ ข้อมูลเหล่านี้บ่งชี้ว่าการสแกนกระดูกอาจยังคงมีบทบาทในการประเมินก่อนการผ่าตัดสำหรับผู้ป่วยมะเร็งตับชนิดเฮปาโตเซลล์ูลาร์คาร์ซิโนมาที่ได้รับการพิจารณาให้เข้ารับการปลูกถ่ายตับ

ORIGINAL ARTICLE

Effect of a Symptom Management Program Combined with Acupressure Massage on Recovery of Bowel Function after Open Abdominal Surgery in Colorectal Cancer Patients in the Intensive Care Unit

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KEYWORDS

acupressure massage; bowel function after surgery; open abdominal surgery; colorectal cancer

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ABSTRACT

Postoperative gastrointestinal dysfunction can affect bowel function recovery, particularly in patients undergoing open abdominal surgery for colorectal cancer who are treated in the intensive care unit. This can lead to serious complications and increased treatment costs. This Quasi-Experimental Study aimed to compare bowel functional recovery after open abdominal surgery among patients with colorectal cancer between an experimental group receiving an acupressure massage program combined with symptom management and a control group receiving traditional nursing care. The sample group consisted of 44 colorectal cancer patients (≥ 20 years) who underwent open abdominal surgery and were admitted to the surgical intensive care unit at Thammasat University Hospital. They were divided into a control group ($n=22$) and an experimental group ($n=22$) using convenience sampling. The experimental group received a symptom management program combined with acupressure massage for 5 days after surgery. This involved daily trunk and leg movements for 10–15 minutes, combined with acupressure massage at Zusanli (ST36) twice daily for 10 minutes each time. The control group received standard nursing care. The research instruments included a program of acupressure massage combined with symptom management, a personal information questionnaire, bowel function recovery assessment, and a behavioral assessment for managing postoperative bowel dysfunction. Data were analyzed using the Mann–Whitney U test and Friedman test. The study found that Patients with colorectal cancer who underwent open abdominal surgery and subsequently received a symptom management program combined with acupressure massage had significantly higher average scores for bowel function recovery on days 3 to 5 post-operatively compared to the control group receiving only conventional nursing care ($p < 0.05$). Research results show that this program can effectively aid in the rehabilitation of bowel function after surgery in patients receiving treatment in the critical care unit.

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Introduction

Colorectal cancer is a major public health problem in Thailand. According to the 2023 statistics of the National Cancer Institute, it is the second most common cancer, second to Liver and Bile Duct Cancer, among males at 17.1% and the third most common, second to Breast and Cervical Cancer, among females at 9.7%. The incidence of colorectal cancer has been steadily increasing, with an average of approximately 15 deaths per day, or 5,476 deaths per year. In 2021–2022, there were 256 and 315 patients with colon and rectal cancer, respectively, admitted to Thammasat University Hospital. Currently, treatment options for colon and rectal cancer include surgery, chemotherapy, and radiation therapy. The primary treatment is surgical removal of all affected areas, followed by chemotherapy or radiation

therapy as indicated. According to the Ministry of Public Health statistics in 2023, a total of 990,829 patients were admitted for intestinal diseases, of whom 304,390 (30.72%) underwent surgery. At Thammasat University Hospital during 2021–2022, 56.2% and 59.6% of patients underwent open abdominal surgery. Open abdominal surgery causes injury to intestinal tissue due to direct contact with the intestines during the surgery, resulting in stimulation of the secretion of inflammatory substances that affect the intestinal muscles. This, combined with general anesthesia and opioid painkillers, which have the side effect of reducing intestinal contractions, causes postoperative bowel dysfunction known as postoperative ileus (POI). This condition can occur in any part of the gastrointestinal tract, but is most severe in the large intestine¹. The risk of developing postoperative bowel

dysfunction has been reported to range from approximately 10% to 30%². Among these patients, 170,947 (9.2%) were diagnosed with postoperative bowel obstruction, and the incidence among colorectal cancer patients ranged from 17.4% to 34.9%³. Common signs and symptoms include bloating, no flatulence, no bowel movements, no bowel sounds, abdominal pain, nausea, and vomiting. This results in a delay in starting to eat food by mouth, increased pain from the surgical wound, slow wound healing, and a delay in starting to move or get out of bed after surgery. This can result in collapsed lungs and lung infections. An Australian study found that postoperative bowel obstruction resulted in longer hospital stays (8 vs. 5 days, $p<0.001$) and a higher rate of complications such as pneumonia (15.2% vs. 8.1%, $p=0.027$) and a 26.4% higher total cost of inpatient care (AU\$37,690 vs. AU\$29,822, $p<0.001$)⁴. Therefore, it is important to promote the rapid recovery of intestinal function after surgery.

Postoperative bowel function recovery refers to the return of the body's ability to digest and absorb fluids and nutrients, as well as eliminate waste products from the body, through normal bowel movements⁵. In general, in patients undergoing abdominal surgery, functional recovery of the small intestine occurs first within 6-24 hours, followed by gastric recovery within 24-48 hours, and colon within 48-72 hours or 3 days after surgery⁶. Postoperative bowel recovery can be assessed by the rate of bowel movement, bloating, gas, defecation, and the rapid initiation of eating⁷. According to a study by Lluís and Biondo⁸ reported that between 2010 and 2018, the incidence of delayed bowel recovery after colorectal surgery due to intestinal insufficiency ranged from 2% to 54%. Further, Incidents of POI have been reported to vary from 7% to 27%, even when enhanced recovery protocols are implemented⁴. Delayed bowel recovery may prolong postoperative rehabilitation and lead to patient discomfort and psychological stress, particularly among patients admitted to the intensive care unit (ICU), where continuous monitoring and the presence of medical equipment may restrict mobility and interfere with rehabilitation activities. This is a common problem among patients recovering from major abdominal surgery in the ICU. As a result, patients require assistance with self-care and symptom management to facilitate recovery. Nurses play a crucial role in promoting rehabilitation during this phase. Promoting bowel function recovery is largely due to nurses' inability to perform nursing tasks independently. Although pharmacological interventions may be limited, nurses can independently implement non-pharmacological interventions that support recovery, particularly early postoperative mobilization. However, for patients receiving care in the intensive care unit (ICU), physical mobilization is often limited. Most patients are connected to monitoring devices or life-support equipment and may not be physically stable or ready for movement. These conditions significantly restrict the ability to stimulate early physical activity during the postoperative period⁹.

Literature review and first-hand experience. In the care of patients after abdominal surgery, it was found that properly performing activities to promote bowel recovery will reduce complications, lower medical costs, and shorten the length of hospital stay. Proper and consistent postoperative recovery activities are crucial. For post-abdominal surgery patients to properly perform postoperative recovery activities, they must be prepared through systematic

instruction and training. Therefore, the researchers applied the symptom management concept proposed by Dodd et al.¹⁰, in conjunction with a literature review. It consisted of three steps: assessment of the experience of postoperative ileus symptoms, management strategies for postoperative bowel prolapse symptoms (education, skills training, practice), and evaluation of postoperative bowel ileus symptoms. The researchers therefore applied bed mobility promotion and leg exercises to patients in the intensive care unit (ICU). This included systematic movement of the trunk and legs. Rapid postoperative body movement helped reduce bowel prolapse, including side-turning, foot exercises, and Passive Range of Motion (PROM) or active exercise. Body movement activates mechanical receptors that stimulate the parasympathetic autonomic nervous system, including the vagus nerve originating from the medulla oblongata, which enhances motility of the small intestine and proximal colon, and the pelvic splanchnic nerves arising from sacral spinal cord segments S2-S4, which facilitate motility of the distal colon. Both send nerve impulses to stimulate cells in the enteric nervous system, releasing the neurotransmitter acetylcholine, which stimulates intestinal motility¹¹. Combined with the concept of acupressure¹², Acupoint Stomach, also known as ST36 or Zusanli, is part of the stomach meridian, as indicated in the textbook. It plays a crucial role in enhancing gastrointestinal (GI) function. By stimulating ST36, one can help regulate stomach qi and address issues such as stomach pain, vomiting, reduced GI function, abdominal distention, diarrhea, and constipation¹³, resulting in reduced symptoms of bowel dysfunction after surgery and promoting recovery of bowel function. Physical therapy is generally believed to aid recovery and prevent acute complications after surgery. Therefore, non-pharmacological care, an independent and easily implemented role for nurses, involves promoting rapid physical movement after surgery. However, in ICU patients, most of whom have monitoring or life-support equipment and are not physically ready, stimulating movement is limited and requires greater caution in promoting mobility. The researchers therefore sought to integrate alternative medicine with conventional medicine, a significant challenge in patient care. However, there are no well-designed randomized trials specifically studying the effects of early physical therapy interventions on various aspects of health, particularly bowel dysfunction after open-abdominal colon surgery in critically ill patients. Consequently, this program provides nurses with actionable care, integrating acupressure with movements specifically designed for ICU patients. This approach fills a gap in ICU care where patients are unable to walk or move quickly.

In this study, the researcher applied the symptom management conceptual framework proposed by Dodd et al.¹⁰, in combination with a physiological framework. Assessment is followed by identifying the focus for intervention strategies. The intervention strategies may be targeted at one or more components of the individual's symptom experience to achieve one or more desired outcomes. Symptom management is a dynamic process, often requiring changes in strategies over time or in response to acceptance or lack of acceptance of the strategies devised¹⁴. The researchers applied the symptom management concept proposed by Dodd et al.¹⁰ through a three-step process. This process helps patients gain a clearer understanding of their problems and utilize appropriate symptom

management strategies. Nurses and the overall picture provide knowledge, skills training, and practical application, and evaluate outcomes from bowel function recovery, which includes physical movement. Stimulating mechanical receptors and acupressure increases vagus nerve activity through various methods such as vagus nerve stimulation (VNS), which in turn stimulates the parasympathetic nervous system and increases blood flow to the intestines¹⁵. This leads to increased intestinal contractions, reducing post-surgical bowel dysfunction and promoting recovery of bowel function.

The objective of this study is to compare the mean postoperative bowel function recovery scores between colorectal cancer patients undergoing open abdominal surgery who received a symptom management program combined with acupressure and those who received conventional nursing care in the intensive care unit.

Materials and Methods

This study employed a non-randomized, matched-pair, sequential quasi-experimental study, time series design 5 day after surgery, and included the colorectal cancer patients aged ≥ 20 years who underwent open abdominal surgery and were admitted to the surgical intensive care unit at Thammasat University Hospital, were selected using convenience sampling, 44 people, divided into a control group of 22 people and an experimental group of 22 people, selected specifically according to the specified qualifications. If they meet the requirements, they will be automatically added to a group. Matched-pair techniques were employed to ensure similarity between the control and experimental groups in terms of gender, body mass index, and postoperative blood potassium levels. Participants with comparable characteristics were paired and then allocated accordingly. To prevent contamination between the control and experimental groups, data from the control group were collected first, followed by data collection from the experimental group.

Inclusion criteria were determined as: 1. Underwent open abdominal colon and rectal surgery. 2. Received general anesthesia. 3. Was admitted to the intensive care unit for more than 24 hours. If the patient is intubated, such as with an endotracheal tube, tracheostomy tube, or high-flow nasal cannula, Positive End Expiratory Pressure (PEEP) must be maintained at no more than 5 cmH₂O. 4. There are no contraindications to acupressure, including acute infection, inflammation at the massage site, deep vein thrombosis, contagious skin conditions, severe osteoporosis, fractures, or fractures at the surgical site of metal or artificial joints, or a history of abnormal bleeding or taking blood-thinning medications. 5. Be conscious, able to communicate in Thai, and willing to cooperate in the research. Patients with the following conditions were considered ineligible: 1. Severe complications, including circulatory failure and severe infection. 2. Unable to complete the study program (5 days). 3. If the participant experiences any changes in their symptoms during the study, such as symptoms that constitute contraindications to massage, their participation in the study will be immediately terminated. 4. If the participant fails to cooperate, potentially causing harm. 5. Death.

The researcher selected a sample group based on the specified criteria. Upon admission to the hospital, the patient was informed of the objectives, procedures, and duration of the program. The researcher collected data by building rapport, explaining the objectives, and requesting cooperation. The researcher divided the sample group into two groups: a control group and an experimental group. Data was collected from the control group first, followed by the experimental group, to prevent contamination. During the data collection process, the researcher performed all activities, and the research assistant was only responsible for assessing bowel function recovery using the assessment tool.

The experimental group received comprehensive knowledge about the meaning, causes, and factors contributing to symptoms, effects, and methods to promote bowel recovery (trunk and leg exercises) during ICU treatment. Additionally, the benefits of acupressure were explained, along with the steps and methods researchers would use with patients one day prior to surgery. Following this, the researchers conducted the following activities:

On the first day after surgery, turn the patient's side every two hours. Since the wound will be very sore during the first 24 hours, it encourages movement that does not exacerbate pain.

On the second day after surgery, I perform foot and ankle exercises. Perform ankle flexion and extension for 5 minutes on each side at a rate of 15 times per minute and perform 15 circular movements of the ankle once daily.

On the third and fifth days after surgery, perform passive range of motion (PROM) exercises on both legs for 10-15 minutes once daily.

For patients who can move their bodies, perform active exercises. For patients who cannot exercise or move their bodies, nurses perform passive exercises, particularly on the legs and lower body. Together with the researcher, acupressure was performed on the Zusanli (ST-36) area, beginning on the first day after surgery. The massage lasted 3-5 minutes per side, twice daily, starting on the first day after surgery (between 8:00 AM and 10:00 AM and 3:00 PM and 5:00 PM). The study was conducted for five consecutive days. Afterward, the subjects were allowed to ask questions. During the process, vital signs (heart rate and blood pressure level on bedside monitors, if available) and patients' reports of discomfort were carefully monitored to ensure patients' safety.

Patients in the control group received routine nursing care provided by professional nurses in the surgical intensive care unit at Thammasat University Hospital. The researcher established a rapport and collected personal data. The researcher assessed recovery of bowel function using the Bowel Function Recovery Assessment. The control group was evaluated at 5 p.m. five days after surgery. On the fifth day after surgery, the researcher provided education, skills training, and a manual for symptom management, along with acupressure, for patients with colon and rectal cancer undergoing open abdominal surgery.



Figure 1 Location of ST36 (Stomach 36 or Zusanli).

Note. ST36 is located at lateral to the tibia, and three cun (equal to the width of the patient's four fingers at the level of proximal interphalangeal joint of the index finger) down from the patella. Photo by Kanyarat Atthasing

Data for analysis was extracted from the hospital's electronic records and recorded in a structured data collection form, including:

Part 1: Data collection tools consisted of:

1. Personal data questionnaire. The researcher developed this questionnaire based on a review of relevant literature. The questionnaire consists of short answers and a checklist of 15 items. Questions included age, gender, underlying medical conditions, weight, height, body mass index (BMI), type of surgery, history of abdominal surgery, amount of blood loss during surgery, duration of surgery, anesthesia received, pain medication received after surgery, use of a ventilator, restriction or immobility after surgery for more than 24 hours, and serum potassium level one day after surgery. The researcher interviewed the sample and the patient's file. The questionnaire was completed within one day after surgery.

2. Intestinal function recovery assessment by Phomphon⁵. The questionnaire consists of a checklist of 4 items. The results of the four intestinal function assessments were then summed up. The lowest score was 4 points, while the highest score was 16 points. A score of 4-7 points indicated poor bowel function recovery, a score of 8-11 points indicated medium bowel function recovery, and a score of 12-16 points indicated good intestinal function recovery.

Part 2: The experimental instrument consisted of a program of acupressure combined with symptom management for functional bowel recovery after open abdominal surgery. The activity steps included education about surgery, postoperative complications, postoperative behavior, patient care in the intensive care unit, acupressure to promote functional bowel recovery, and evaluation of activity results. functional bowel recovery, and evaluation of activity outcomes.

Part 3: The experimental control instrument consisted of the postoperative bowel syndrome management behavior assessment. This researcher-developed assessment was used to evaluate patients' behaviors related to the management of postoperative bowel syndrome. It covered postoperative

behavioral strategies, including turning, leg exercises, and six multiple-choice questions. The assessments were conducted daily after surgery, days 1-5, at 5:00 PM. Compliance criteria were defined as follows: a pass was defined as achieving at least 80% compliance, equivalent to successful completion of at least 5 out of 6 activities, whereas a failure was defined as achieving less than 80% compliance. This instrument was used by researchers to monitor adherence to the symptom management and acupressure program. Actual performance was recorded. In cases where participants were unable to perform the activities independently, the researchers helped ensure proper implementation of the program.

After data collection was completed, statistical analysis was performed. Data was analyzed using the Statistical Package for Social Sciences (SPSS). Descriptive statistics, including frequency, percentage, mean, and standard deviation (SD), were used to analyze general characteristics as well as disease- and treatment-related data. Differences in general characteristics and disease and treatment-related variables between the experimental and control groups were analyzed using the Chi-square test. Data normality was assessed using the Shapiro-Wilk test, which indicated that the data were not normally distributed. Therefore, differences in postoperative bowel function recovery between the experimental and control groups were analyzed using the Mann-Whitney U test, with a significance level of 0.05. Changes in postoperative bowel function recovery from postoperative days 1 to 5 within and between groups after receiving the intervention were analyzed using the Friedman test.

Results

The distribution of gender was equal between the two groups, with males accounting for 50% of the participants. The most common age group in the experimental and control groups was 60 years and above. When comparing the characteristics of the two patient groups, there was no statistically significant difference between the experimental and control groups ($p > 0.05$), as shown in Table 1.

Table 1 Comparisons of demographic and clinical characteristics between intervention and control groups.

Variables	Intervention group (n = 22)	Control group (n = 22)	p-value
Gender			
Male	11 (50%)	11 (50%)	1.000 ^a
Female	11 (50%)	11 (50%)	
Age, Mean $\pm$ SD, years	61.8 $\pm$ 13.0	55.2 $\pm$ 13.2	0.185 ^b
BMI (kg/m ²) Mean $\pm$ SD	22.21 $\pm$ 3.6	21.95 $\pm$ 3.3	0.557 ^b
Comorbidity			
do not have	6 (27.3%)	5 (22.7%)	0.324 ^b
1 disease	4 (18.2%)	8 (36.4%)	
2 diseases	5 (22.7%)	6 (27.3%)	
3 diseases	4 (18.2%)	3 (13.6%)	
4 or more diseases	3 (13.6%)	-	
Previous abdominal surgery	8 (36.4%)	14 (63.6%)	0.070 ^a
Duration of surgery (min)			
More than 180 minutes	20 (90.9%)	20 (90.9%)	1.000 ^a
Less than 180 minutes	2 (9.1%)	2 (9.1%)	
Blood loss during surgery			
More than 500 ml	4 (18.2%)	7 (31.8%)	0.296 ^a
Less than 500 ml	18 (81.8%)	15 (68.2%)	
Pain relievers			
Fentanyl	9 (40.9%)	15 (68.2%)	0.067 ^b
Morphine	10 (45.5%)	3 (13.6%)	
Local anesthetic	3 (13.6%)	4 (18.2%)	
How to take painkillers			
Intravenous injection	19 (86.4%)	18 (81.8%)	0.680 ^b
Epidural	3 (13.6%)	4 (18.2%)	
Use of a ventilator			
Yes	6 (27.3%)	11 (50%)	0.215 ^a
No	16 (72.7%)	11 (50%)	
Limited or no physical movement for more than 24 hours after surgery			
No physical activity for $\geq$ 24 hours	11 (50%)	15 (68.2%)	0.358 ^a
There was physical activity $\leq$ 24 hours.	11 (50%)	7 (31.8%)	
Blood potassium level 1 day after surgery			
< 3.5 mEq/L	5 (22.7%)	6 (27.3%)	0.805 ^b
3.5-5 mEq/L	15 (68.2%)	14 (63.6%)	
> 5 mEq/L	2 (9.1%)	2 (9.1%)	

BMI, body mass index., a = Fisher's Exact Test, b = Pearson Chi-Square

A comparison of postoperative bowel function recovery between the experimental and control groups showed no statistically significant differences on postoperative days 1 and 2 among colorectal cancer patients who underwent open abdominal surgery. The Mann-Whitney U values were 208 and 199, with Asymp. Sig. (2-tailed) values of 0.210 and 0.298, respectively. In contrast,

postoperative bowel function recovery scores on days 3, 4, and 5 differed significantly between the experimental and control groups among colorectal cancer patients who underwent open abdominal surgery (Mann-Whitney U = 47.50, 49.00, and 30.50, respectively; Asymp. Sig. (2-tailed) < 0.001), indicating statistical significance at the 0.05 level.

The results demonstrated that colorectal cancer patients who underwent open abdominal surgery and received the symptom management program combined with acupressure showed significantly higher mean postoperative

bowel function recovery scores on postoperative days 3 to 5 compared with those who received standard nursing care ($p < 0.05$), as shown in Tables 2 and 3.

Table 2 Comparison of postoperative bowel function recovery between the experimental and control groups

postoperative bowel function recovery	Control group		Intervention group		Mann-Whitney U	z	Asymp. Sig. (2-tailed)
	Mean Rank	Sum of Rank	Mean Rank	Sum of Rank			
Day 1 after surgery	20.95	461	24.05	529	208	-1.254	0.210
Day 2 after surgery	20.55	452	24.45	538	199	-1.041	0.298
Day 3 after surgery	13.66	300.50	31.34	689.50	47.50	-4.784	< 0.001
Day 4 after surgery	13.73	302	31.27	689.50	49	-4.632	< 0.001
Day 5 after surgery	12.89	283.50	32.11	706.50	30.50	-5.052	< 0.001

Statistical significance level at 0.05

Table 3 Comparison of mean rank of bowel function recovery scores from days 1 to 5 between the experimental and control groups

Group	Mean bowel function recovery score					χ^2	p-value
	Mean Rank						
	POD 1	POD 2	POD 3	POD 4	POD 5		
Intervention group	1.16	1.84	3.27	3.98	4.75	82.13	< 0.001
Control group	1.30	2	3.20	3.91	4.59	75.62	< 0.001

POD = Postoperative Day, Statistical significance level at 0.05

χ^2 และ p-value เป็นผลของการวิเคราะห์ภายในกลุ่ม (Friedman test)

Discussion

A study on the effects of a symptom management program combined with acupressure massage after open abdominal surgery in colorectal cancer patients in the Intensive Care Unit found a statistically significant ($p < 0.05$) difference in bowel function recovery scores between the experimental group receiving the symptom management program and the control group receiving standard nursing care on days 3 to 5 after surgery ($p < 0.05$). This study also observed no statistically significant difference between groups on days 1–2 after surgery. This is attributed to the immediate post-operative period encompassing a neuroactive phase characterized by autonomic nervous system dysfunction and initial suppression of gastrointestinal motility. This process begins with surgical stress and bowel manipulation, activating various neural pathways and ultimately leading to temporary bowel motility dysfunction. Following this initial neural inhibition, an inflammatory phase emerges within the first 24 hours and can last up to 72 hours. This phase is triggered by the surgical wound in the intestine, leading to the activation of intestinal immune cells and the influx of inflammatory mediators or cytokines. These inhibit smooth muscle contraction by modulating the function of myenteric neurons, resulting in prolonged bowel stasis. Along with the use of opioids as the primary pain management medication for wound pain in the first 72 hours after surgery, it also contributes significantly to postoperative ileus (POI) due to its effects on opioid receptors in the gastrointestinal tract¹¹. Previous studies have shown that patients experience

improved bowel function recovery in 3 days after surgery. Consistent with the study by Koesanthia et al.¹ reported that physical movement within the first 72 hours post-surgery improved bowel function recovery in patients, with better bowel function recovery scores on day 3 compared to day 1 after surgery. Previous studies have shown that early physical movement plays a crucial role in improving gastrointestinal function after surgery by stimulating several neurohormonal mechanisms. These mechanisms include increased vagus nerve activity, increased parasympathetic nervous system activity, modulation of sympathetic nervous system function, and influence on hormonal mechanisms. Understanding these physiological effects, researchers can apply physical movement strategies to reduce postoperative ileus (POI) and accelerate bowel function recovery. Numerous studies have shown that gastrointestinal (GI) symptoms are common in ICU patients, with up to 62% experiencing at least one gastrointestinal problem for at least one day. Bowel dysfunction is a significant prognostic factor in critically ill patients. This dysfunction can lead to various complications, including longer hospital stays, delayed recovery, higher morbidity and mortality rates, and can negatively impact the patient's quality of life after discharge. Because patients in the ICU have greater mobility limitations, physical movement can be particularly effective in addressing these issues. Therefore, the researchers focused on the movement of the trunk and legs. A study by Morisawa et al.¹⁷ reported that passive exercise of the trunk and legs in cardiac surgery patients in the critical care unit significantly increased the mean bowel motility sound. Furthermore,

previous studies have shown that increased health education can reduce postoperative complications¹⁷. The researchers integrated education, physical activity promotion, and acupressure massage to improve bowel function. This aligns with the study by Zia et al.¹⁹ reported that early patient education, breathing exercises, physical activity, connective tissue massage, and transcutaneous electrical nerve stimulation in patients after open hysterectomy significantly improved the time to flatulence and defecation. However, due to limitations in the nursing context, connective tissue massage and electrical nerve stimulation were applied by nurses, demonstrating the positive effect of ST36 acupressure on early postoperative gastrointestinal function in patients undergoing colorectal cancer surgery. This is consistent with the study by Chao et al.²⁰ reported that ST-36 acupressure reduced the time to the first flatulence and promoted gastrointestinal function in patients after abdominal surgery, with the experimental group showing better bowel motility than the control group within 2-3 days post-surgery. Furthermore, a study by Liu et al.¹² reported that acupressure significantly reduced the time to the first flatulence after surgery and improved bowel motility in the experimental group. Therefore, it can be concluded that a symptom management program combined with acupressure massage significantly contributed to bowel function recovery after open abdominal surgery in colorectal cancer patients in the Intensive Care Unit. Patients receiving the program had significantly higher bowel function recovery scores than those receiving standard nursing care ($p < 0.05$).

When analyzing these promising results, several limitations of this study should be taken into consideration. Firstly, it's a single-center study, which might limit the applicability of the findings to other settings. Secondly, due to the multifactorial nature of the subject, we suggest conducting future subgroup analyses based on factors such as the type of surgery and its location to reduce variability. Thirdly, the severity of abdominal distention was self-reported, making it somewhat subjective and dependent on timing, which could introduce potential bias. Furthermore, we did not assess the precise percentage of ERAS adherence at the research hospital, which might affect the robustness of the acupressure effect size. Lastly, we did not follow up with participants post-discharge to explore the long-term impacts of acupressure on gastrointestinal function. Future investigations should address these limitations, ideally utilizing a multicenter approach with a larger sample size. Additionally, conducting a longitudinal study with follow-ups is crucial for evaluating the long-term effects and potential complications.

Conclusion

This study provides evidence that leg and trunk movements combined with nurse-administered acupressure positively influence gastrointestinal function in the early post-operative CRC surgery period. Hospitals should consider incorporating nurse-administered acupressure into clinical practice to enhance early recovery for patients. This program may be an option for colorectal cancer patients after open abdominal surgery who are admitted to the ICU and show noticeable improvement during postoperative days 3–5.

Ethical Approval

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Human Research Ethics Committee of Thammasat University Hospital (protocol code TUH-EC-OO-0-004/68; approval date: 21 March 2025). Informed consent was obtained from all participants or their legal representatives.

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บทความวิจัย

ผลของโปรแกรมการจัดการอาการร่วมกับการนวดกดจุดต่อการฟื้นตัวของการทำงานของลำไส้หลังการผ่าตัดเปิดช่องท้องในผู้ป่วยมะเร็งลำไส้ใหญ่และทวารหนักในหอผู้ป่วยวิกฤต

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คำสำคัญ

นวดกดจุด; การทำงานของลำไส้หลังผ่าตัด;
การผ่าตัดแบบเปิดช่องท้อง; มะเร็งลำไส้ใหญ่
และทวารหนัก

บทคัดย่อ

ภาวะการทำงานของระบบทางเดินอาหารผิดปกติหลังผ่าตัด ส่งผลต่อการฟื้นตัวด้านการทำหน้าที่ของลำไส้โดยเฉพาะผู้ป่วยที่เข้ารับการผ่าตัดแบบเปิดช่องท้องในผู้ป่วยมะเร็งลำไส้ใหญ่และทวารหนักที่รักษาตัวในหอผู้ป่วยวิกฤต ซึ่งอาจก่อให้เกิดภาวะแทรกซ้อนร้ายแรงและเพิ่มค่าใช้จ่ายในการรักษา การวิจัยครั้งนี้เป็นการศึกษาทั้งทดลองมีวัตถุประสงค์เพื่อเปรียบเทียบการฟื้นตัวด้านการทำหน้าที่ของลำไส้หลังผ่าตัดแบบเปิดช่องท้องในผู้ป่วยมะเร็งลำไส้ใหญ่และทวารหนักระหว่างกลุ่มที่ได้รับการนวดกดจุดร่วมกับการจัดการอาการกับกลุ่มที่ได้รับการพยาบาลแบบเดิม กลุ่มตัวอย่างคือผู้ป่วยมะเร็งลำไส้ใหญ่ และทวารหนักที่ได้รับการผ่าตัดแบบเปิดช่องท้อง เข้ารับการรักษาวัดที่หอผู้ป่วยวิกฤตศัลยกรรมในโรงพยาบาลธรรมศาสตร์เฉลิมพระเกียรติ จำนวน 44 ราย (อายุ 20 ปีขึ้นไป) เป็นกลุ่มควบคุม 22 ราย และกลุ่มทดลอง 22 ราย คัดเลือกกลุ่มตัวอย่างแบบตามสะดวก กลุ่มทดลองได้รับการจัดการอาการร่วมกับการนวดกดจุด เป็นเวลา 5 วันหลังการผ่าตัด โดยการเคลื่อนไหวลำตัวและขาวันละ 1 ครั้ง ครั้งละ 10-15 นาที ร่วมกับการนวดกดจุดบริเวณ Zusanli (ST-36) วันละ 2 ครั้ง ครั้งละ 10 นาที ส่วนกลุ่มควบคุมได้รับการพยาบาลตามมาตรฐาน เครื่องมือวิจัยประกอบด้วยโปรแกรมการนวดกดจุดร่วมกับการจัดการอาการ แบบสอบถามข้อมูลส่วนบุคคล แบบประเมินการฟื้นตัวด้านการทำหน้าที่ของลำไส้ และแบบประเมินพฤติกรรมในการจัดการกับอาการลำไส้หยุดทำหน้าที่หลังผ่าตัด วิเคราะห์ข้อมูลด้วยสถิติ Mann-Whitney U test และ Friedman test ผลการศึกษาพบว่าผู้ป่วยมะเร็งลำไส้ใหญ่และทวารหนักที่เข้ารับการผ่าตัดแบบเปิดช่องท้องภายหลังได้รับโปรแกรมการจัดการอาการร่วมกับการนวดกดจุดมีคะแนนเฉลี่ยการฟื้นตัวด้านการทำหน้าที่ของลำไส้หลังผ่าตัดวันที่ 3 ถึง 5 มากกว่ากลุ่มที่ได้รับการพยาบาลตามแบบเดิมอย่างมีนัยสำคัญทางสถิติที่ระดับ 0.05 ($p < 0.05$) ผลการวิจัยแสดงให้เห็นว่าโปรแกรมนี้อาจช่วยในการดูแลฟื้นฟูการทำงานของลำไส้หลังผ่าตัดในผู้ป่วยที่ได้รับการรักษาในหอผู้ป่วยวิกฤตได้อย่างมีประสิทธิภาพ

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ORIGINAL ARTICLE

Mortality Rate and Associated Factors Among Patients with Septic Arthritis at Pranangklao Hospital

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KEYWORDS

septic arthritis; mortality; comorbidities; complications

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ABSTRACT

Septic arthritis is a medical emergency resulting from infection within a joint. Delayed diagnosis can lead to irreversible joint damage, permanent disability, or dissemination of the infection into the bloodstream, which can ultimately result in death. Despite significant advancements in modern medical care, the mortality rate in patients with septic arthritis remains high. This retrospective cohort study aimed to determine the mortality rate and prognostic factors associated with septic arthritis in hospitalized patients in Pranangklao Hospital between January 1, 2020, and December 31, 2024. Patients aged 15 years and older who were admitted with a diagnosis of septic arthritis were included. Factors associated with mortality were analyzed using univariate analysis and multivariate logistic regression. Mortality was defined as death occurring during hospital admission. A total of 130 patients were enrolled, 124 cases of bacterial arthritis alone, 4 cases of tuberculous arthritis alone, and 2 cases of concurrent bacterial and tuberculous arthritis. No cases of viral, fungal, or parasitic arthritis were identified. The overall in-hospital mortality rate was 12 patients (9.3%). Factors significantly associated with mortality through multivariate logistic regression included chronic kidney disease stage 4–5 ($p=0.002$), oligoarticular or polyarticular involvement ($p=0.015$), hip joint infection ($p=0.03$), and concurrent bloodstream infection ($p=0.012$). While patients who underwent surgical drainage demonstrated a significant association with reduced mortality in the univariate analysis ($p=0.009$), this association was no longer statistically significant after adjustment in the multivariate logistic regression. The findings of this study provide valuable insight into the prognostic factors influencing mortality among patients with septic arthritis. Awareness and early recognition of these risk factors, followed by timely and appropriate treatment, may help reduce mortality rates and improve quality of life in patients affected by this condition.

Introduction

Septic arthritis is a medical emergency characterized by infection within the joint space, most commonly affecting the hip, knee, and ankle joints^{1,2}. The global incidence ranges from 4 to 15 cases per 100,000 person-years, with similar rates reported in the United States, Western Europe, and South Korea³⁻⁶. In Thailand, data from 2018–2020 showed an incidence of 22.6–23.3 cases per 100,000 person-years, highest in the northeastern region and among individuals aged over 70 years (70.2 per 100,000)⁷. Bacterial arthritis, primarily caused by *Staphylococcus aureus*, *Streptococcus spp.*, and *Enterobacteriaceae*, is the most common etiology⁸. In Thailand, *Burkholderia pseudomallei* is more prevalent, particularly in the northeast^{9,10}. Septic arthritis is usually monoarticular (80%), with mortality ranging from 5%–20%, rising to more than 50% in polyarticular cases^{11,12}. Poor prognostic factors include advanced age, comorbidities, such as diabetes, liver or chronic kidney disease, malignancy, prosthetic

joint infection, and polyarticular involvement⁹. Treatment typically involves antibiotics with joint drainage via needle aspiration or surgical debridement; however, evidence on the optimal treatment remains inconclusive¹³⁻¹⁵. Most Thai studies have focused on northeastern populations^{10,14,16-19}, while data from central and other regions is limited. This study aims to investigate mortality and prognostic factors in adult septic arthritis patients in Pranangklao Hospital to inform regional management strategies and guide antibiotic and treatment planning.

Materials and Methods

Study design

A retrospective cohort study conducted on patients diagnosed with septic arthritis who were admitted for inpatient treatment in Pranangklao Hospital between January 1, 2020, and December 31, 2024.

Population

This study included patients aged 15 years and older who were diagnosed with septic arthritis based on medical records. Patients were identified using the International Classification of Diseases (ICD)-10 codes M00 (pyogenic arthritis) or M01 (direct infections of the joint in infectious and parasitic diseases classified elsewhere), recorded as either the principal diagnosis, comorbidity, or complication in inpatient medical records. Diagnostic verification was performed through a comprehensive review of patients' medical records, surgical reports, laboratory data, and both microbiological and histopathological findings. Patients with incomplete, missing medical records, electronic data unavailable or a higher suspicion of alternative diagnoses other than septic arthritis, were excluded from the study.

The demographic data included sex, age, body mass index (BMI), comorbidities, pre-existing joint diseases, and specific details of the septic arthritis, such as the affected joint site, number of joint involvements, and whether the infection occurred in a native or prosthetic joint. Additional data included risk factors for infection, use of immunosuppressive agents or corticosteroids, laboratory results, synovial fluid analysis, identified pathogens, treatment modalities, and clinical outcomes.

Definitions for Study Eligibility and Variables

1. Septic arthritis was defined according to the Newman criteria²⁰ as follows:

A: Isolation of pathogenic organisms from synovial fluid or synovial tissue.

B: Isolation of pathogenic organisms from extra-articular sites, such as blood, sputum, urine, or pus cultures, in the presence of clinical features consistent with septic arthritis.

C: No organism isolated from either synovial fluid or other sites, but with supportive evidence of infection, including:

(i) histological or radiological findings suggestive of joint infection, and/or

(ii) aspiration of turbid synovial fluid.

2. Septic arthritis of bacterial origin was classified as definite or possible/probable. Definite bacterial arthritis was defined by the isolation of bacterial pathogens from cultures or Gram stain obtained from synovial fluid or synovial tissue. Possible/probable bacterial arthritis was defined as cases fulfilling the Newman criteria²⁰ for septic arthritis without microbiological confirmation in synovial fluid or synovial tissue. Given that septic arthritis secondary to bacterial infection is common than other pathogens and associated with substantial morbidity and mortality, cases with negative culture results were classified as septic arthritis of presumed bacterial origin.

3. Mortality was defined as death occurring during hospitalization while the patient was admitted as an inpatient and prior to hospital discharge.

4. Corticosteroid use was defined as a history of receiving prednisolone or an equivalent corticosteroid at a dose of ≥ 5 mg/day for more than 30 consecutive days within the 3 months preceding the onset of septic arthritis.

5. Immunosuppressive therapy was defined as the use of any immunosuppressive agents, including conventional Disease-Modifying Antirheumatic Drugs (DMARDs), biologic DMARDs, targeted DMARDs, or other immunosuppressive agents, within 3 months prior to the onset of septic arthritis.

6. Bloodstream infection was defined as the isolation of any pathogenic organism from blood cultures, including bacteria, viruses, fungi, parasites, or *Mycobacterium spp.*

Sample size

Based on a review of the literature, a study by Andreassen et al.²¹ reported a mortality rate of 9.3% among patients with septic arthritis. The sample size was calculated using an infinite population proportion formula, with a significance level (α) of 0.05, a statistical power of 80%, an expected proportion (p) of 0.093, and a margin of error (d) of 0.05.

The required sample size was estimated to be 130 participants.

Statistical analysis

Categorical variables were presented as frequency and percentages, continuous variables were expressed as mean $\pm$ standard deviation (SD) for normal distribution or median with interquartile range (IQR) for nonnormal distribution. Comparisons between inpatient death and survival were performed using the Chi-square test or Fisher's exact test for categorical variables, and the independent t-test or Mann-Whitney U test for continuous variables. A univariate analysis was used to screen for prognostic factors associated with mortality. Variables with a p -value < 0.1 in the univariate analysis were subsequently included in a stepwise multivariate logistic regression. A p -value < 0.05 was considered statistically significant. Statistical analyses were performed using Stata 14.0 (StataCorp, TX, USA).

Results

A total of 130 patients with septic arthritis were included, predominantly female (51.5%) with a median age of 62 years (IQR 48.0–71.0). Most cases were bacterial arthritis alone ($n=124$), followed by tuberculous arthritis alone ($n=4$), and concurrent bacterial and tuberculous infections ($n=2$). In the bacterial arthritis group, two patients were diagnosed with gonococcal arthritis; one male and one female. Neither patient underwent joint aspiration; however, *Neisseria gonorrhoeae* was identified from cervical (female) and urethral (male) swab cultures. Twelve patients (9.3%) died during hospitalization, while 118 (90.7%) survived. Native joint infections accounted for 92.3% and prosthetic joint infections for 7.7%, all of which occurred in the survival group. The knee was the most affected joint (64.5%), followed by the wrist (13.2%), ankle (9.9%), and hip (6.6%). Infection at hip ($p=0.032$) and ankle ($p=0.098$) were more frequent in the death group. Monoarthritis was observed in 83.4% and oligo- or polyarthritis in 16.6% of patients, multiple joint involvement was significantly higher in the death group (50.0% vs. 13.0%, $p=0.004$). No viral, fungal, or parasitic arthritis was detected (Table 1).

Comorbidities

Diabetes mellitus (DM) was the most common comorbidity (30%), followed by hyperlipidemia, cardiovascular disease (CVD), and chronic kidney disease (CKD) stage 4-5. The prevalence of DM ($p=0.042$), hyperlipidemia ($p=0.038$), and CKD stage 4-5 ($p<0.001$) was significantly higher in the death group. Thirty-one patients (23.8%) had pre-existing joint disease, of whom two were in the death group had systemic lupus erythematosus (SLE) and psoriatic arthritis (PsA), respectively. The duration of fever

(median 2.0 days; IQR 2.0-7.0) and joint pain (median 3.5 days; IQR 2.0-7.0) before admission was comparable between groups. Concurrent infections at hospital admission were identified in 56.1% of patients. Bloodstream infection was

the most frequent (21.5%), followed by skin and soft tissue (16.1%) and urinary tract infections (13.1%). Bloodstream infection ($p=0.004$) and urinary tract infection ($p=0.052$) occurred more often in the death group (Table 1).

Table 1 Baseline characteristics

Characteristics	Total (n=130)	Death (n=12)	Survival (n=118)	p-value
Type of arthritis, n (%)				1.000
Bacterial arteritis alone	124 (95.4)	12 (100.0)	112 (94.9)	
Tuberculous arthritis alone	4 (3.1)	-	4 (3.4)	
Bacterial and tuberculous arthritis	2 (1.5)	-	2 (1.7)	
Native joint, n (%)	120 (92.3)	12 (100.0)	108 (91.5)	0.597
Prosthetic joint, n (%)	10 (7.7)	-	10 (8.5)	1.000
Gender, n (%)				0.367
Female	67 (51.5)	8 (66.7)	59 (50.0)	
Male	63 (48.5)	4 (33.3)	59 (50.0)	
Age (years), median (IQR)	62.0 (48.0 - 71.0)	71.0 (58.5 - 75)	60.5 (47.0 - 70.0)	0.141
Body mass index (BMI) (kg / m2), median (IQR)	23.0 (20.4 - 26.3)	22.8 (20.4 - 26.0)	23.0 (20.5 - 26.6)	0.875
Joint (native joint) (n=120), n (%)				
Knee	78 (64.5)	7 (58.3)	71 (60.2)	0.753
Ankle	12 (9.9)	3 (25)	9 (7.6)	0.098
Hip	8 (6.6)	3 (25)	5 (4.2)	0.032
Wrist	16 (13.2)	1 (8.3)	15 (12.7)	1.000
Elbow	4 (3.3)	1 (8.3)	3 (2.54)	0.345
Sacroiliac	1 (0.8)	-	1 (0.8)	1.000
Number of joint involvements (n=120)	120 (100.0)	12 (100.0)	108 (100.0)	0.004
Monoarthritis	100 (83.4)	6 (50.0)	94 (87.0)	
Oligoarthritis	19 (15.8)	6 (50.0)	13 (12.0)	
Polyarthritis	1 (0.8)	-	1 (1.0)	
Corticosteroids used, n (%)	4 (3.1)	-	4 (3.4)	1.000
Immunosuppressive agents used, n (%)	6 (4.6)	1 (8.3)	5 (4.2)	0.447
Comorbidities, n (%)				
Diabetes mellitus (DM)	39 (30.0)	7 (58.3)	32 (27.1)	0.042
Hyperlipidemia	37 (28.5)	7 (58.3)	30 (25.4)	0.038
Cardiovascular disease (CVD)	9 (6.9)	2 (16.7)	7 (5.9)	0.195
Chronic kidney disease (CKD) stage 4-5	8 (6.2)	5 (41.7)	3 (2.5)	<0.001
HIV	5 (3.8)	-	5 (4.2)	1.000
Liver cirrhosis	7 (5.4)	-	7 (5.9)	1.000
Malignancies	7 (5.4)	2 (16.7)	5 (4.2)	0.127
Pre-existing joint disease, n (%)	31 (23.8)	2 (16.7)	29 (24.6)	0.730
Rheumatoid arthritis (RA)	3 (2.3)	-	3 (2.5)	1.000
Systemic lupus erythematosus (SLE)	4 (3.1)	1 (8.3)	3 (2.5)	0.324
Psoriatic arthritis (PsA)	2 (1.5)	1 (8.3)	1 (0.8)	0.177
Other	22 (16.9)	-	22 (18.6)	1.000

Table 1 Continued

Characteristics	Total (n=130)	Death (n=12)	Survival (n=118)	p-value
Duration of fever before hospital visit (days), median (IQR)	2.0 (2.0 - 7.0)	2.0 (1.0 - 8.0)	2.5 (2.0 - 7.0)	0.134
Duration of joint pain and swelling before hospital visit (days), median (IQR)	3.5 (2.0 - 7.0)	2.5 (2.0 - 6.5)	4.0 (2.0 - 7.0)	0.264
Concomitant infection at other sites at initial admission, n (%)				
Pneumonia	3 (2.3)	1 (8.3)	2 (1.7)	0.254
Urinary tract infection	17 (13.1)	4 (33.3)	13 (11.0)	0.052
Skin and soft tissue infection	21 (16.1)	4 (33.3)	17 (14.4)	0.104
Infective spondylodiscitis	3 (2.3)	-	3 (2.5)	1.000
Cervicitis	1 (0.8)	-	1 (0.8)	1.000
Bloodstream infection	28 (21.5)	7 (58.3)	21 (17.8)	0.004

IQR: interquartile range

Laboratory and microbiology

In the death group, both white blood cell (WBC) count ($p=0.002$) and serum creatinine level ($p=0.006$) were significantly higher than in the survival group. Joint aspiration or surgical drainage was performed in 126 patients, while four did not undergo aspiration. Among the four patients who did not undergo arthrocentesis, two patients (one male and one female) were diagnosed with gonococcal arthritis based on the identification of *Neisseria gonorrhoeae* from urethral and cervical swab specimens, respectively. Both patients presented with septic arthritis involving the wrist joint. The remaining two patients were diagnosed with septic arthritis of the sacroiliac joint ($n=1$) and the hip joint ($n=1$) based on magnetic resonance imaging (MRI) findings. All four patients were categorized in the survival group. The synovial fluid WBC count tended to be higher in the death group ($p=0.083$). Gram staining identified organisms in 27.8% of cases, including gram-positive bacteria in 15.9% and gram-negative in 11.9%. Synovial fluid cultures were positive in 38.9% of cases, with *Streptococcus agalactiae* (12.7%) and *Staphylococcus aureus* (9.5%) as the predominant pathogens. Among 6 cases of tuberculous arthritis, 1 was

culture-confirmed, and five were diagnosed via polymerase chain reaction (PCR). Blood cultures were positive in 27.7% of patients, most commonly isolating *S. agalactiae* (12.3%) and *S. aureus* (9.2%). No significant differences in microbiological profiles were observed between death and survival groups. Among patients diagnosed with septic arthritis according to the Newman criteria²⁰, 58 patients were classified as category A, 18 as category B, and 54 as category C. Within category A, pathogenic organisms were identified in synovial fluid or synovial tissue. Of these, 49 had bacterial pathogens identified from synovial fluid culture, and one patient had *Mycobacterium tuberculosis* identified by culture. Three patients had organisms detected by Gram stain despite negative synovial fluid cultures. Additionally, five patients were diagnosed with tuberculous arthritis based on positive PCR for *Mycobacterium tuberculosis* from synovial tissue biopsy specimens. Two patients had evidence of both bacterial infection identified by culture and concomitant tuberculous arthritis confirmed by PCR for *Mycobacterium tuberculosis*. However, no statistically significant difference was observed between the survival and death groups (Table 2).

Table 2 Baseline laboratory at admission and microbiology results

Characteristics	Total (n=130)	Death (n=12)	Survival (n=118)	p-value
WBC in serum ($\times 10^3$ cells/uL), median (IQR)	12.0 (8.9 - 16.2)	19.5 (13.8 - 28.1)	11.5 (8.4 - 15.6)	0.002
Serum creatinine (mg/dl), median (IQR)	0.9 (0.6 - 1.3)	1.5 (1.0 - 4.4)	0.9 (0.6 - 1.2)	0.006
Hemoglobin (g/dl), mean (SD)	10.8 (2.3)	10.0 (2.2)	10.9 (2.5)	0.200
ESR (mm/hr) (n=119), median (IQR)	102.0 (85.0 - 117.0)	102.0 (99.0 - 106.5)	101.0 (84.0 - 117.0)	0.624
CRP (mg/dl) (n=117), median (IQR)	147.0 (69.9 - 234.0)	212.9 (148.1 - 298.2)	139.9 (56.7 - 226.0)	0.062
Arthrocentesis, n (%)	126 (96.9)	12 (100)	114 (96.6)	1.000
WBC in synovial fluid ($\times 10^3$ cells/uL) (n=113), median (IQR)	69.6 (34.7 - 131.5)	109.9 (58.8 - 186.9)	67.9 (33.5 - 126.1)	0.083

Table 2 Continued

Characteristics	Total (n=130)	Death (n=12)	Survival (n=118)	p-value
Organisms detected on synovial fluid Gram stain (n=126), n (%)	35/126 (27.8)	3/12 (25.0)	32/114 (28.1)	1.000
Gram-positive bacteria	20 (15.9)	2 (16.7)	18 (15.8)	
Gram-negative bacteria	15 (11.9)	1 (8.3)	14 (12.3)	
Pathogen identified in synovial fluid (n=126), n (%)	49/126 (38.9)	5/12 (41.6)	44/114 (38.7)	1.000
<i>Streptococcus agalactiae</i>	16 (12.7)	1 (8.3)	15 (13.2)	1.000
<i>Staphylococcus aureus</i>	12 (9.5)	2 (16.7)	10 (8.8)	0.320
<i>Klebsiella pneumoniae</i>	2 (1.6)	1 (8.3)	1 (0.9)	0.182
<i>Pseudomonas aeruginosa</i>	2 (1.6)	1 (8.3)	1 (0.9)	0.182
<i>Mycobacterium tuberculosis</i>	1 (0.8)	-	1 (0.9)	1.000
Others	16 (12.7)	-	16 (14.0)	
Pathogen identified in hemoculture, n (%)	36 (27.7)	5 (41.6)	31 (26.3)	0.311
<i>Streptococcus agalactiae</i>	16 (12.3)	1 (8.3)	15 (12.7)	
<i>Staphylococcus aureus</i>	12 (9.2)	4 (33.3)	10 (8.5)	
Others	8 (6.2)	-	6 (5.1)	
Newman criteria, n (%)				0.456
A	58 (44.7)	5 (41.7)	53 (44.9)	
B	18 (13.8)	3 (25.0)	15 (12.7)	
C	54 (41.5)	4 (33.3)	50 (42.4)	

IQR: interquartile range, SD: standard deviation

Treatment and complications

Of 130 patients, 4 patients did not undergo joint aspiration, 38 patients underwent needle aspiration alone, and 88 patients underwent surgical drainage, either by open arthrotomy or arthroscopy, with or without concurrent needle aspiration. Surgical drainage was more common in the survival group (70.3%) than in the death group, where conservative treatment predominated (58.3%; $p=0.055$). Among those who underwent surgery, the procedure was performed earlier in survival group (median 27.0 hours vs.

72.0 hours, $p=0.052$). All 35 patients (39.8%) who underwent surgical drainage within 24 hours survived. Among 126 bacterial arthritis cases, the median intravenous antibiotic duration was longer in the survival group (median 14.0 days; IQR 12.0-17.0) than in the death group (median 11.0 days; IQR 5.5-21.5). Complications such as acute kidney injury ($p<0.001$), septic shock ($p<0.001$), hospital- or ventilator-acquired pneumonia ($p=0.037$), and pressure sores ($p=0.018$) were significantly more frequent in the death group (Table 3).

Table 3 Treatment and complications of patients with septic arthritis

Characteristics	Total (n=130)	Death (n=12)	Survival (n=118)	p-value
Arthrocentesis, n (%)				1.000
None	4 (3.1)	-	4 (3.4)	
Needle aspiration alone	38 (29.2)	7 (58.3)	31 (26.3)	
Open arthrotomy / arthroscopy with or without needle aspiration	88 (67.7)	5 (41.7)	83 (70.3)	
Number of needle aspiration, median (IQR)	1.0 (0.0-1.0)	1.0 (1.0-1.0)	1.0 (0.0-1.0)	0.115
Treatment, n (%)				0.055
Conservative treatment	42 (32.3)	7 (58.3)	35 (29.7)	
Surgical drainage	88 (67.7)	5 (41.7)	83 (70.3)	
Duration from admission to surgical drainage (hours) (n=88), median (IQR)	31.0 (18.0 - 76.0)	72.0 (48.0 - 216.0)	27.0 (18.0 - 72.0)	0.052

Table 3 Continued

Characteristics	Total (n=130)	Death (n=12)	Survival (n=118)	p-value
Surgical drainage within 24 hours after admission (n=88), n (%)	35 (39.8)	-	35 (39.8)	0.152
Duration of intravenous antibiotic therapy (days) (n=126), median (IQR)	14.0 (11.0 - 27.0)	11.0 (5.5 - 21.5)	14.0 (12.0 - 27.0)	0.146
Complications, n (%)				
Acute kidney injury	33 (25.4)	11 (91.7)	22 (17.2)	<0.001
Septic shock	18 (13.9)	11 (91.7)	7 (5.9)	<0.001
Hospital/ventilator acquired pneumonia	9 (6.9)	3 (25.0)	6 (5.1)	0.037
Congestive heart failure	7 (5.4)	2 (16.7)	5 (4.2)	0.127
Pressure sore	7 (5.4)	3 (25.0)	4 (3.4)	0.018
Gastrointestinal bleeding	19 (14.6)	3 (25.0)	16 (13.6)	0.382
Osteomyelitis	9 (6.9)	2 (16.7)	7 (5.9)	0.195

IQR: interquartile range

Prognostic factors associated with the mortality

In the univariate analysis, several factors were found to be significantly associated with in-hospital mortality among patients with septic arthritis. Patients with CKD stage 4-5 had a markedly increased risk of death (HR 9.13, 95% CI: 2.74-30.45), as did those with malignancies (HR 4.08, 95% CI: 0.86-19.25). The presence of pre-existing joint disease, particularly psoriatic arthritis, was also associated with higher mortality (HR 8.83, 95% CI: 1.10-70.93). Patients with oligo- or polyarthritis had an increased risk of death compared with those with monoarthritis (HR 3.39, 95% CI: 1.05-10.93). In terms of joint involvement, infection of the ankle joint (HR 3.51, 95% CI: 0.93-13.25) and hip joint (HR 4.17, 95% CI: 1.08-16.13) were both associated with higher mortality. The presence of concurrent infections at hospital admission, such as urinary tract infection (HR 3.14, 95% CI: 0.91-10.83) and bloodstream infection (HR 3.68, 95% CI: 1.15-11.83), particularly *S. aureus* bacteremia (HR 5.38, 95% CI: 1.51-19.18), was also significantly correlated with mortality. Regarding in-hospital complications, the occurrence of acute kidney injury (HR 25.28, 95% CI: 3.21-198.83), septic shock (HR 59.66, 95% CI: 7.59-469.25), hospital-or ventilator-

acquired pneumonia (HR 4.12, 95% CI: 1.08-15.70), and congestive heart failure (HR 3.82, 95% CI: 0.81-18.02) were associated with increased mortality risk. Elevated serum WBC count (HR 1.04, 95% CI: 1.02-1.05) and serum creatinine level (HR 1.26, 95% CI: 1.08-1.46) at admission were also significant predictors of death. Conversely, receiving surgical drainage (HR 0.16, 95% CI: 0.04-0.63) and a longer duration of intravenous antibiotic therapy (HR 0.87, 95% CI: 0.78-0.96) were identified as protective factors against in-hospital mortality.

When using a multivariate logistic regression, several independent predictors of in-hospital mortality were identified. The presence of CKD stage 4-5 (HR 15.19, 95% CI: 2.76-83.43, $p=0.002$), oligo- or polyarthritis (HR 6.32, 95% CI: 1.42-28.13, $p=0.015$), hip joint infection (HR 15.31, 95% CI: 2.56-91.50, $p=0.003$), and concurrent bloodstream infection (HR 7.95, 95% CI: 1.59-39.85, $p=0.012$) were all significantly associated with increased in-hospital mortality. In contrast, a longer duration of intravenous antibiotic therapy (HR 0.80, 95% CI: 0.71-0.90, $p<0.001$) was found to be significantly associated with decreased mortality (Table 4).

Table 4 Logistic regression analysis of the mortality in septic arthritis patients

Variables	Univariate logistic regression		Multivariable logistic regression	
	HR (95% CI)	p-value	HR (95% CI)	p-value
Age	1.02 (0.98 - 1.05)	0.369		
Diabetes	2.66 (0.80 - 8.70)	0.107		
Chronic kidney disease stage 4-5	9.13 (2.74 - 30.45)	<0.001	15.19 (2.76 - 83.43)	0.002
Malignancies	4.08 (0.86 - 19.25)	0.076		
Pre-existing joint disease	0.66 (0.14 - 3.05)	0.594		
Psoriatic arthritis	8.83 (1.10 - 70.93)	0.040		
Oligoarthritis or polyarthritis	3.39 (1.05 - 10.93)	0.041	6.32 (1.42 - 28.13)	0.015
Knee septic arthritis	0.51 (0.15 - 1.69)	0.272		
Ankle septic arthritis	3.51 (0.93 - 13.25)	0.064		
Hip septic arthritis	4.17 (1.08 - 16.13)	0.039	15.31 (2.56 - 91.50)	0.003

Table 4 Continued

Variables	Univariate logistic regression		Multivariable logistic regression	
	HR (95% CI)	p-value	HR (95% CI)	p-value
Pneumonia	4.51 (0.56 - 36.17)	0.156		
Urinary tract infection	3.14 (0.91 - 10.83)	0.070		
Skin and soft tissue infection	1.59 (0.41 - 6.12)	0.499		
Bloodstream infection	3.68 (1.15 - 11.83)	0.029	7.95 (1.59 - 39.85)	0.012
Staphylococcus aureus bacteraemia	5.38 (1.51 - 19.18)	0.009		
Surgical drainage	0.16 (0.04 - 0.63)	0.009		
Duration of intravenous antibiotic therapy	0.87 (0.78 - 0.96)	0.008	0.80 (0.71 - 0.90)	<0.001
Acute kidney injury	25.28 (3.21 - 198.83)	0.002		
Septic shock	59.66 (7.59 - 469.25)	<0.001		
Hospital/ventilator acquired pneumonia	4.12 (1.08 - 15.70)	0.038		
Congestive heart failure	3.82 (0.81 - 18.02)	0.091		
WBC in serum	1.04 (1.02 - 1.05)	<0.001		
Serum creatinine	1.26 (1.08 - 1.46)	0.002		
WBC in synovial fluid	1.00 (1.00 - 1.00)	0.186		
CRP	1.00 (1.00 - 1.01)	0.129		

HR: hazard ratio, CI: confidence interval

Discussion

In our study, the in-hospital mortality rate in patients with septic arthritis was 9.3%, consistent with previous reports ranging from 7% to 15%^{13,15,21-23}. Most infections involved native joints (92.3%), while prosthetic joint infections (7.7%) occurred more frequently than in other studies (1-2%)^{24,25}. The majority were bacterial arthritis alone (95.4%), with 3.1% tuberculous arthritis alone, and 1.5% concurrent bacterial and tuberculous infections. No viral, fungal, or parasitic cases were identified. The median age was 62 years, align with prior international^{12,22,26-28} and Thai studies^{14,16,18} showing predominance among older adults. Monoarthritis was most common (83.4%), followed by oligoarthritis (15.8%) and polyarthritis (0.8%), consistent with previous findings²⁹. The knee was the most frequently affected joint, followed by the wrist, ankle, and hip.

Streptococcus agalactiae (12.7%) was the predominant pathogen, followed by *Staphylococcus aureus* (9.5%), differing from international studies where *S. aureus* predominates^{8,13,22,28,30} but consistent with Thai data reporting *S. agalactiae* as the leading cause¹⁵⁻¹⁸. Interestingly, *Burkholderia pseudomallei* was not identified in our cohort, contrasting with several studies conducted in northeastern Thailand, where *B. pseudomallei* has been reported as one of the leading causative pathogens of septic arthritis^{10,14,16,18}. However, in this study, among the 126 patients diagnosed with septic arthritis due to bacterial infection, four patients did not undergo arthrocentesis. Among those who underwent arthrocentesis, bacterial pathogens were identified in synovial fluid cultures in only 49 patients, while three additional patients had organisms detected by Gram stain despite negative synovial fluid cultures. We postulated that patients with negative results from both synovial fluid culture and Gram stain were also likely to have septic

arthritis of bacterial origin, given that bacterial infections are more common than other etiologies, are associated with substantial morbidity and mortality, and typically respond to antibiotic therapy. Nevertheless, findings in the mortality group should be interpreted with caution. These patients may have had true bacterial arthritis but failed to respond to antibiotic treatment or developed severe complications. Alternatively, their condition may have been attributable to non-bacterial infections.

Based on clinical data derived from the literature review and the data collected in this study, univariate analysis identified several factors that were significantly associated with mortality. Variables with a *p*-value <0.1 were subsequently included in a multivariate logistic regression analysis, which demonstrated that CKD stage 4-5 (HR 15.19, *p*=0.002), oligo- or polyarthritis (HR 6.32, *p*=0.015), hip joint infection (HR 15.31, *p*=0.003), and concurrent bloodstream infection (HR 7.95, *p*=0.012) as independent prognostic factors associated with the mortality. These findings are consistent with previous studies identifying CKD and bacteremia as major mortality risk factors^{22,26,31}. Hip joint infections, often difficult to drain, were also associated with poorer outcomes. However, a longer duration of antibiotic therapy (HR 0.80, *p*<0.001) was found to be associated with reduced mortality. This finding should be interpreted with caution. After reviewing the medical records, it was revealed that all 12 patients who died were receiving antibiotic therapy at the time of death, but subsequently developed complications that ultimately led to death.

Surgical drainage was associated with improved survival in univariate analysis (HR 0.16, *p*=0.009), but not in multivariate analysis, consistent with prior conflicting evidence on this treatment approach^{13,15}. In our study, earlier surgical drainage—particularly within 24 hours—

was observed only among survival group, suggesting that timely intervention may improve outcomes, especially in hip infections.

Finally, the survival group had longer intravenous antibiotic courses (median 14.0 days) than the death group (median 11.0 days). As previously mentioned, all 12 patients in the death group died while receiving antibiotic therapy and subsequently developed complications that led to death; therefore, these findings should be interpreted with caution. Nevertheless, according to standard treatment guidelines, the recommended duration of antibiotic therapy is 2-6 weeks depending on pathogen, joint involved, and presence of osteomyelitis². These findings reinforce that prolonged intravenous antibiotics and early surgical intervention may improve survival in septic arthritis, particularly among patients with high-risk factors such as CKD, oligo- or polyarticular disease, hip involvement, or concurrent bloodstream infection.

This study possesses several strengths: (1) Broad inclusion criteria: this study enrolled patients with septic arthritis caused by bacteria, *Mycobacterium species*, viruses, fungi, and parasites, providing a wider epidemiological scope than previous studies that often excluded non-bacterial causes. Although only bacterial and tuberculous arthritis were identified. (2) Inclusion of both native and prosthetic joints: patients with infections of both native and prosthetic joints were analyzed, enhancing the generalizability of findings, as prior studies frequently excluded prosthetic joint infections. (3) Regional contribution: conducted in central region of Thailand, this study adds valuable epidemiological data, complementing previous reports mainly from the northeastern region. (4) Comprehensive dataset: the study incorporated detailed demographic, laboratory, microbiological, and treatment data, providing an integrated view of patient outcomes.

However, several limitations should be considered: (1) Single-center retrospective design: limits generalizability and the retrospective nature of this study limit the ability to establish causal relationships between potential risk factors and mortality in septic arthritis. (2) Incomplete medical records: some clinical data were missing or inaccessible due to incomplete documentation or unavailable historical results. (3) Uncaptured confounding variables: factors such as smoking history, prior intra-articular injections, or unrecorded medications were unavailable. (4) Assessment limited to in-hospital mortality: dysfunction or delayed post-discharge mortality were not assessed. (5) Limited microbiological confirmation: only 76 patients had microbiological evidence of infection with bacteria or *Mycobacterium tuberculosis* based on culture, Gram stain, or PCR from synovial fluid, synovial tissue, or other relevant sites, the remaining 54 patients had no identifiable pathogens and were classified as having bacterial arthritis, although alternative infectious etiologies cannot be excluded.

Conclusion

Septic arthritis remains a significant clinical problem associated with mortality. Our study identified several prognostic factors associated with death, including chronic kidney disease stage 4-5, oligo- or polyarthritis, hip joint infection, and concurrent bloodstream infection. Moreover, patients who underwent surgical drainage also demonstrated a trend toward better survival outcomes. Therefore, in patients presenting with these risk factors,

early surgical drainage combined with adequate duration intravenous antibiotic therapy may help reduce mortality from septic arthritis. However, as this study was a retrospective analysis, further studies are needed to establish causal relationships between these factors and mortality in patients with septic arthritis.

Ethical Approval

The study was approved by the Institutional Human Research Ethics Committee of Pranangklaao Hospital (EC 50/2568; approval date: 28 August 2025). Informed consent was obtained from all participants or their legal representatives.

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บทความวิจัย

อัตราการเสียชีวิตและปัจจัยที่เกี่ยวข้องของผู้ป่วยโรคข้ออักเสบติดเชื้อในโรงพยาบาลพระนั่งเกล้า

อรรถพร บุญยอด

กลุ่มงานอายุรกรรม โรงพยาบาลพระนั่งเกล้า

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บทคัดย่อ

โรคข้ออักเสบติดเชื้อเป็นภาวะฉุกเฉินทางการแพทย์ที่เกิดจากการติดเชื้อในข้อ หากได้รับการวินิจฉัยล่าช้า อาจส่งผลให้ข้อสูญเสียการทำงาน เกิดภาวะทุพพลภาพ หรือมีการแพร่กระจายของเชื้อออกนอกข้อไปในกระแสเลือด จนทำให้เกิดการเสียชีวิตตามมาในที่สุด แม้ว่าในปัจจุบันการแพทย์จะมีการพัฒนาและทันสมัยขึ้น แต่อัตราการเสียชีวิตในผู้ป่วยโรคข้ออักเสบติดเชื้อก็ยังคงสูงอยู่ การศึกษานี้เป็นการศึกษาแบบย้อนหลัง เพื่อดูอัตราการเสียชีวิตและปัจจัยพยากรณ์โรคที่สัมพันธ์กับการเสียชีวิตของผู้ป่วยโรคข้ออักเสบติดเชื้อที่ได้รับการรักษาแบบผู้ป่วยในในโรงพยาบาลพระนั่งเกล้า ระหว่างวันที่ 1 มกราคม พ.ศ. 2563 ถึง 31 ธันวาคม พ.ศ. 2567 ทำการศึกษาแบบพรรณาย้อนหลัง ในผู้ป่วยที่มีอายุตั้งแต่ 15 ปีขึ้นไป วิเคราะห์หาปัจจัยที่มีผลต่อการเสียชีวิตโดยใช้สถิติ univariate analysis และ multivariate logistic regression กลุ่มตัวอย่างทั้งหมด 130 คน เป็นข้ออักเสบจากการติดเชื้อแบคทีเรียอย่างเดียว 124 คน เป็นข้ออักเสบจากการติดเชื้อวัณโรคอย่างเดียว 4 คน เป็นข้ออักเสบจากการติดเชื้อแบคทีเรียและวัณโรคร่วมกัน 2 คน โดยไม่พบผู้ป่วยที่มีข้ออักเสบจากการติดเชื้อไวรัส เชื้อรา และเชื้อปรสิตเลย พบอัตราการเสียชีวิตของผู้ป่วยโรคข้ออักเสบติดเชื้อ 12 คน คิดเป็นร้อยละ 9.3 ปัจจัยที่สัมพันธ์กับการเสียชีวิตเมื่อวิเคราะห์ด้วยสถิติ multivariate logistic regression ได้แก่ การมีโรคประจำตัวเป็นไตวายเรื้อรังระยะ 4-5 ($p=0.002$) การมีข้ออักเสบติดเชื้อมากกว่า 1 ข้อขึ้นไป (oligoarthritis หรือ polyarthritis) ($p=0.015$) การติดเชื้อที่ข้อสะโพก ($p=0.03$) และการมีภาวะติดเชื้อในกระแสเลือดร่วมด้วย ($p=0.012$) ในขณะที่ผู้ป่วยที่ได้รับการรักษาด้วยการผ่าตัดระบายน้ำไขข้อ (surgical drainage) ($p=0.009$) มีความสัมพันธ์กับการเสียชีวิตที่ลดลงใน univariate analysis แต่กลับไม่พบความแตกต่างอย่างมีนัยสำคัญทางสถิติเมื่อวิเคราะห์ด้วย multivariate logistic regression ข้อมูลจากการศึกษานี้ทำให้ทราบถึงปัจจัยพยากรณ์โรค การตระหนักถึงปัจจัยเสี่ยงดังกล่าวและให้การวินิจฉัยร่วมกับการรักษาได้อย่างเหมาะสม อาจช่วยให้อัตราการเสียชีวิตในผู้ป่วยโรคข้ออักเสบติดเชื้อลดลงและผู้ป่วยมีคุณภาพชีวิตที่ดีขึ้นได้

ORIGINAL ARTICLE

Effects of a Health Behavior Modification Program Based on the Transtheoretical Model Among Overweight Healthcare Personnel at Amnatcharoen Hospital

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ABSTRACT

Overweight and obesity are major public health problems leading to non-communicable diseases. As key role models in health promotion, public health personnel must manage their own health to maintain credibility and effectively promote healthy behaviors in communities. A health behavior modification program can help improve personnel's overall health. Therefore, this quasi-experimental study aimed to examine the effects of a health behavior modification program on overweight personnel at Amnatcharoen Hospital, using the Stages of Change Theory. The sample included 70 overweight personnel (BMI ≥ 23 kg/m²), evenly assigned to the experimental and control groups, with 35 participants in each group. The experimental group received a 12-week health behavior modification program that included awareness-raising, reinforcement, training in diet and exercise skills, and monitoring and feedback. In contrast, the control group received regular care. The research instruments consisted of a program tested for content validity and a questionnaire with a reliability of 0.76. The data was analyzed using descriptive statistics and Analysis of Covariance (ANCOVA), with $p < 0.05$ for statistical significance. The study found that after participating in the health behavior modification program, statistically significant between-group differences were observed in knowledge of health behavior modification ($F(1, 64) = 17.415, p < 0.001, \eta^2 = 0.214$) and body fat percentage ($F(1, 64) = 6.297, p = 0.015, \eta^2 = 0.090$), with the experimental group demonstrating more favorable outcomes than the comparison group. No statistically significant differences were found in health behaviors ($F(1, 64) = 1.396, p = 0.242$), attitudes toward health behavior modification ($F(1, 64) = 1.700, p = 0.197$), or body mass index (BMI) ($F(1, 64) = 2.329, p = 0.132$). In conclusion, the program based on the stages of change theory was effective in enhancing knowledge and reducing body fat percentage among overweight personnel. However, no significant differences were observed in health behaviors, attitudes, or BMI during the study period. This study highlights the feasibility of applying the proposed approach within health promotion systems, particularly in the systematic development of workplace health promotion programs for personnel. Furthermore, the findings support the formulation of policies or practical guidelines for healthcare institutions to implement staff health promotion initiatives alongside the provision of services to the public.

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Introduction

Overweight and obesity are major public health problems both nationally and globally, leading to the increasing severity of chronic diseases. Overweight and obesity are increasingly common and are contributing factors to complications and diseases such as diabetes, hypertension, hyperlipidemia, gout, and fatty liver, which can lead to cardiovascular disease and stroke¹. A 2022 report from the World Obesity Federation found that approximately 800 million people worldwide are obese. Of these, 39 million are children under 5 years of age, and approximately 340 million are children and adolescents aged 5-19 years. Meanwhile, the World Health Organization (WHO) reported that in 2016, the

prevalence of overweight and obesity among adults was 39%, or more than 1.9 billion people. Thailand is also facing this problem. Currently, Thailand has the second-highest obesity rate in ASEAN, after Malaysia, and this number continues to increase—according to data from the Division of Non-Communicable Diseases, Department of Disease Control, Ministry of Public Health. The prevalence of overweight or obesity in adults in 2021 was reported to be 47.2%, an increase from 34.7%². The incidence of obesity in Thailand has increased by more than 30 percent, or there are more than 20 million obese patients in the total population. The results of the 6th Thai National Health Examination Survey 2019-2020 found that 42.2% of Thais aged 15 years and

over are obese, and 39.4%³ are centrally located—data from the Department of Health. The Ministry of Public Health reported that during the period 2021–2023, the prevalence of overweight and obesity among individuals aged 18–59 years showed an increasing trend⁴.

The aforementioned problems in the working-age population require resolution and prevention, particularly among personnel. As the Ministry of Public Health is the primary organization responsible for public health, it places great importance on the health of its personnel. It supports and encourages personnel to develop a positive awareness of health care, ensuring strong physical and mental health, enabling them to provide effective services and serve as good examples for the public. In addition to providing health care to the public, Ministry of Public Health personnel are expected to be good role models for health, embodying appropriate health behaviors, such as exercising, eating healthy foods, and avoiding behaviors that put health at risk⁵. Medical and public health personnel are crucial in caring for patients and the public. It is imperative that these personnel maintain healthy behaviors and be role models for the public. Poor health behaviors can negatively impact their image and credibility in providing health care advice to the public.

A 2020 study by Puntiya⁶ on obesity in the medical profession found that 40% of all physicians in the United States are overweight, a relatively high number. Overweight and obesity have many causes, including high-energy diets, decreased exercise, overtime or shift work, and work and school stress. Some of these are due to occupational and daily behavioral factors that are difficult to address. This is consistent with the study by Somnuk et al.⁷, which studied the Prevalence and Factors Related to Metabolic Syndrome in Personnel of Somdejphrajaotaksinmaharaj Hospital. They found that exercise frequency was associated with central obesity. A literature review revealed that applying the Stage of Change Theory to health behavior modification programs can improve individual health behaviors.

Data from annual health examinations among personnel at Amnatcharoen Hospital revealed that some personnel had abnormal results, such as weight, waist circumference, and blood lipid levels. Data from five-year health examinations revealed that overweight personnel were overweight. That is, the body mass index (BMI) was ≥ 23 kg/m². In 2018, there were 336 people; in 2019, 317; in 2020, 333; in 2021, 405; and in 2022, 353. It was found that 1 in 3 personnel are overweight (BMI ≥ 23 kg/m²). Abnormal results from the annual health examination of Amnatcharoen Hospital personnel may lead to future disease. When personnel become ill, it affects their work. Therefore, to help Amnatcharoen Hospital personnel adopt healthy behaviors, promote good health, and serve as role models for the public, the researcher implemented a health behavior modification program for overweight personnel at the Hospital. The results of the study will help promote and modify the health behaviors of Amnatcharoen Hospital personnel.

This study aimed to evaluate the effect of a health behavior modification program on health behavior knowledge, attitudes, BMI, and body fat percentage among overweight hospital personnel.

Materials and Methods

Study Method

This study employed a quasi-experimental research design with a two-group pretest-posttest approach. Seventy overweight personnel (BMI ≥ 23 kg/m²) from Amnatcharoen Hospital were allocated into an experimental group and a comparison group, with 35 participants in each group. The experimental group participated in a 12-week health behavior modification program, while the comparison group received usual care. Data were collected before and after the intervention from August to November 2024. This design allowed for comparison of the effects of the program on health behaviors, knowledge, attitudes, BMI, and body fat percentage.

Population and Sample

The study population consisted of personnel working at Amnatcharoen Hospital with a body mass index (BMI) of 23 kg/m² or higher. Eligible participants were aged 20–59 years, had no chronic diseases or health problems preventing exercise, and voluntarily agreed to participate in the program for the entire 12-week duration. Personnel who were relocating, resigning, or pregnant were excluded. The sample size was calculated using the formula for comparing two independent means, resulting in 27 participants per group. To account for potential dropouts, 10% was added, yielding 35 participants per group, for a total of 70 participants. Participants were assigned to either the experimental group or the comparison group, with 35 participants in each. The experimental group received the 12-week health behavior modification program, while the comparison group received usual care.

Sample Size Calculation

The sample size calculation formula was used to compare the population means of two independent groups⁸. The sample size was 27 participants per group. However, to prevent problems with participants not being able to participate in the program every time or withdrawing from the study, the sample size was increased by 10 percent, resulting in 35 participants per group, for a total of 70 participants.

Research Instruments

The research consisted of two types of instruments: (1) The experimental tools consisted of a health behavior modification program for overweight personnel at Amnatcharoen Hospital. This program applied the theory of behavior change. The activities included education on health behavior modification, obesity and its health effects, nutrition education and food samples, emotional and stress management education, exercise education and demonstrations, exercise training, goal-setting activities for health behavior modification, encouragement and support, and recommendations for appropriate health behavior modification. Data collection included weight, height, and body fat percentage. A supplementary knowledge manual was also provided, along with a health behavior recording form, a behavior change stage assessment form, and a health promotion behavior assessment questionnaire. (2) The tools used for data collection include a questionnaire, which is created by the researcher and divided into five parts as follows:

Part 1: General Information Questionnaire. This section consisted of a demographic questionnaire developed by the researcher. It collected data on gender, age, length of employment, position, type of work, shift work, marital status, income, education level, and average weekly physical activity. The questionnaire contained 14 items in multiple-choice and fill-in-the-blank formats.

Part 2: Health Behavior Questionnaire. This instrument measured health behaviors across three subscales: diet, exercise, and stress management. The questionnaire consisted of 30 items, divided equally into three subscales: diet (10 items), exercise (10 items), and stress management (10 items). Each item was rated on a 5-point Likert scale ranging from 1 (no practice at all) to 5 (regular practice, 6–7 days per week). Subscale scores ranged from 10 to 50 points, and the total score ranged from 30 to 150 points. Higher scores indicated better health behaviors.

Part 3: Knowledge and Understanding of Health Behavior Modification Questionnaire. This questionnaire assessed knowledge and understanding of health behavior modification. It consisted of 15 items in a yes/no format. Each correct answer received 1 point, and each incorrect answer received 0 points. The total score ranged from 0 to 15 points, with higher scores indicating greater knowledge and understanding.

Part 4: Attitudes Toward Health Behavior Modification Questionnaire. This instrument measured attitudes toward health behavior modification. It consisted of 10 items rated on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The total possible score ranged from 10 to 50 points. Higher scores reflected more positive attitudes toward health behavior modification.

Part 5: Body Mass Index and Body Fat Percentage Data Recording Form. This form recorded anthropometric data, including weight, height, body mass index (BMI), and body fat percentage. Body weight and body fat percentage were measured using a body composition analyzer.

Instrument Quality Assessment

Content validity was evaluated by five experts using the Index of Item-Objective Congruence (IOC). Items with IOC values ≥ 0.50 were retained after revision. Reliability was assessed through a pilot test with 30 public health personnel using Cronbach's alpha and KR-20. The overall reliability coefficient of the entire questionnaire was 0.76. The reliability coefficient for the attitude scale was 0.79, and the knowledge questionnaire yielded a KR-20 value of 0.74.

Data Collection

Data collection was divided into two phases, as detailed below:

Experimental Preparation Phase

For the experimental group, the researcher sent a letter to the administrators of Amnatcharoen Hospital requesting permission to conduct the experiment and collect data. Upon receiving permission for the experiment and data collection, the researcher met with the subjects to explain the purpose, procedures, and timeframe for data collection, and to explain their rights to accept or refuse research participation. Upon consent, the researcher had them sign a consent form, for comparison group the researcher sent a letter to the administrators of Yasothon Hospital requesting permission to conduct the experiment and collect data. Upon receiving permission for the experiment and data collection, the researcher met with the subjects to explain the purpose, procedures, and timeframe for data collection, and to explain their rights to accept or refuse research participation. Upon consent, the researcher had them sign a consent form.

Experimental Phase

The researcher conducted the experiment over a total period of 12 weeks. Participants in the experimental group participated in a health behavior modification program, while those in the comparison group were advised to maintain their usual lifestyle and work practices without any intervention from the research program. Outcome measurements were obtained by collecting data on health behaviors, stages of behavior change, body mass index (BMI), and body fat percentage. These variables were assessed both before and after the intervention in both the experimental and comparison groups.

Data Analysis

After collecting all data, the researcher verified its accuracy and analyzed it using a statistical software package. Descriptive statistics, including frequency, percentage, mean, and standard deviation, were used to describe the general characteristics of the sample. Differences between the experimental and comparison groups were analyzed using ANCOVA, controlling for baseline values.

Results

A total of 70 participants were enrolled in the study, as shown in the CONSORT flow diagram (Figure 1). No participants withdrew or were lost to follow-up; therefore, all participants were included in the final analysis.

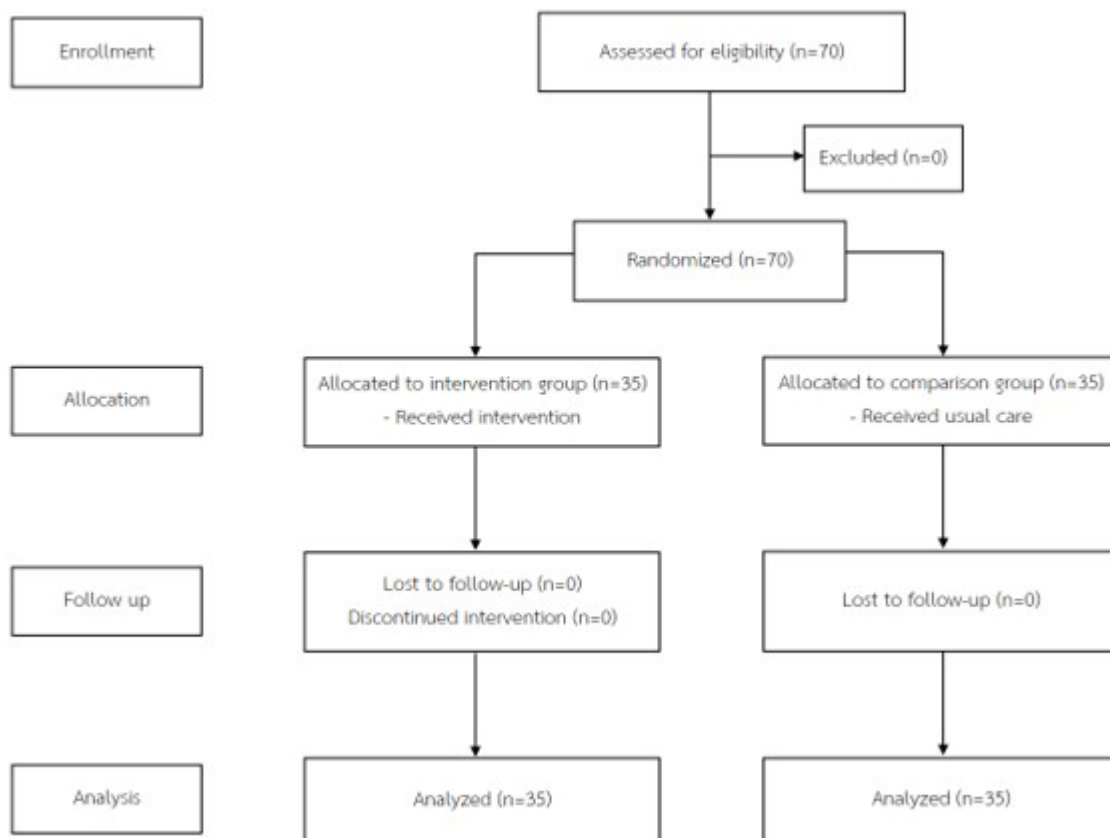


Figure 1 CONSORT flow diagram of the study

General Information: The study found that the majority of the experimental group (91.4%) were female, with an average age of 42.34 years and an average working length of 17.07 years. The majority of the subjects were Ministry of Public Health employees (57.1%), and 62.9% worked shifts. Marital status was married 48.6%. The majority of participants reported a monthly income of 15,000 baht or less (58.6%). Most participants held an educational qualification below a bachelor's degree (38.5%). Exercised an average of 1-2 times per week, 54.3%. The average sleep hours were 6.89 per day. Average phone screen time was 3.54 hours per day 100%. They ate regular food 85.7% of the time and did not purchase dietary supplements 82.9% of the time.

The comparison group was predominantly female (85.7%), with an average age of 43.14 years and an average length of service of 9.58 years. Most participants were temporary employees (61.5%), 82.9% worked shifts, 68.6% were married or in a partnership, and 57.1% had a monthly income between 5,001–10,000 baht. The largest proportion

held an educational qualification below a bachelor's degree (38.5%). More than half (51.4%) did not exercise regularly. The average number of hours sleeping was 5.93 hours per day, with an average daily screen time of 3.40 hours. All participants (100%) ate regular food, and 82.9% did not purchase dietary supplements.

Comparison of the mean and standard deviation of body mass index (BMI) and body fat percentage of the experimental and comparison groups before and after the experiment. Before the experiment, the experimental group had an average body mass index of 29.03 and an average body fat percentage of 39.84; the comparison group had an average body mass index of 29.12 and an average body fat percentage of 38.44. After the experiment, the experimental group had an average body mass index of 28.71 and an average body fat percentage of 39.26; the comparison group had an average body mass index of 29.20 and an average body fat percentage of 38.64, as shown in Table 1.

Table 1 The mean and standard deviation of body mass index (BMI) and body fat percentage in the experimental and comparison groups, measured before and after the intervention.

Variables	Experimental group (n = 35)				Comparison group (n = 35)			
	Before		After		Before		After	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Body Mass Index (BMI)	29.03	4.81	28.71	5.03	29.12	4.46	29.20	4.79
Body fat percentage	39.84	4.81	39.26	5.19	38.44	7.68	38.64	7.43

Comparing the number and percentage of behavioral stages according to the Stages of Change Theory of the experimental and comparison groups before and after the experiment, the experimental group's behavioral stages before and after the experiment were as follows: Before the experiment, the most participants were in the Contemplation stage 57.1%, followed by the Maintenance stage 28.6%, the Pre-contemplation stage 11.4%, and the least number was in the Action stage 2.9%. After the experiment, the largest number of participants were in the Maintenance stage (54.3%), followed by the Contemplation stage (25.7%), the

Action stage (14.3%), and the smallest number in the Pre-contemplation stage (5.7%).

The comparison group's behavioral stages before and after the experiment were as follows: Before the experiment, most participants were in the Action stage (31.4%), followed equally by the Pre-contemplation and Contemplation stages (28.6% each), and the Maintenance stage had the fewest participants (11.4%). After the experiment, most people were in the Action stage (31.4%), followed by the Maintenance stage (28.6%), and the Pre-contemplation and Contemplation stages had the least number (20.0%), as shown in Table 2.

Table 2 Number and percentage of behavioral stages according to the stages of change theory in the experimental and comparison groups before and after the Experiment

Behavioral stages according to the stages of change theory	Experimental group (n = 35)		Comparison group (n = 35)	
	Before	After	Before	After
	Frequency (Percent)	Frequency (Percent)	Frequency (Percent)	Frequency (Percent)
Pre-contemplation stage	4 (11.40)	2 (5.70)	10 (28.60)	7 (20.00)
Contemplation stage	20 (57.10)	9 (25.70)	10 (28.60)	7 (20.00)
Preparation stage	0 (0)	0 (0)	0 (0)	0 (0)
Action stage	1 (2.90)	5 (14.30)	11 (31.40)	11 (31.40)
Maintenance stage	10 (28.60)	19 (54.30)	4 (11.40)	10 (28.60)

A one-way analysis of covariance (ANCOVA) was conducted to compare the effectiveness of the intervention on health behaviors, knowledge and understanding regarding health behavior modification, attitudes toward health behavior modification, body mass index (BMI) and body fat percentage between the experimental and control groups, while controlling for baseline covariates including pre-test scores, income, education level, and job position. After adjusting for the covariates, there was a statistically significant difference in knowledge and understanding

regarding health behavior modification between the two groups, $F(1, 64)=17.415$, $p<0.001$, $\eta^2=0.214$, and body fat percentage, $F(1, 64)=6.297$, $p=0.015$, $\eta^2=0.090$. The experimental group demonstrated a greater reduction in body fat compared to the control group. After adjusting for the covariates, no statistically significant difference was found in BMI between the experimental and control groups, $F(1, 64)=2.329$, $p=0.132$. Similarly, no significant differences were found for attitudes ($p=0.197$) or health behaviors ($p=0.242$). as shown in Table 3.

Table 3 ANCOVA Results Comparing the Experimental Group and the Comparison Group

Outcome Variable	F (1,64)	p-value	Partial η^2
Health behaviors	1.396	0.242	0.022
knowledge and understanding regarding health behavior modification	17.415	<0.001	0.214
attitudes toward health behavior modification	1.700	0.197	0.026
body mass index (BMI)	2.329	0.132	0.035
Body fat percentage	6.297	0.015	0.090

Discussion

The results of the ANCOVA comparing the experimental and comparison groups, after controlling for baseline scores, revealed statistically significant differences in knowledge and understanding regarding health behavior modification ($F=17.415$, $p<0.001$, Partial $\eta^2=0.214$) and body fat percentage ($F=6.297$, $p=0.015$, Partial $\eta^2=0.090$). These findings indicate that the program had a clear and meaningful effect on enhancing participants' knowledge and understanding, with a relatively large effect size observed for the cognitive outcome. The structured educational content covering diet, stress management, exercise, and the benefits of behavior modification likely contributed to these improvements. This finding is consistent with the studies of Tiaotrakul⁹, Chantawat et al.¹⁰, and Charoenbut et al.¹¹, which demonstrated that structured health behavior modification programs and integrated learning innovations significantly improved knowledge and health-related behaviors among participants.

The observed stage progression in the experimental group from predominantly Contemplation (57.1%) at baseline to Maintenance (54.3%) post-intervention is consistent with the Stages of Change model, which conceptualizes behavior change as a progression through five stages: pre-contemplation, contemplation, preparation, action, and maintenance, with meta-analytic evidence supporting the applicability of this model across a wide range of health behaviors, as demonstrated by Hall and Rossi¹². In addition, systematic reviews by Hutchison et al.¹³ have demonstrated that stage-matched interventions, which tailor strategies to an individual's readiness to change, can effectively improve behavioral outcomes, including adherence and sustained behavior change. The program's structured components, including awareness-raising, goal-setting, and reinforcement, appear to have effectively addressed key mechanisms underlying behavior change, such as decisional balance and self-efficacy, facilitating meaningful movement from pre-action to action and maintenance stages. This is consistent with Johnson and colleagues¹⁴, who demonstrated that tailored Stages of Change-based interventions significantly impacted healthy eating, exercise, and managing emotional distress, with participants progressing to Action or Maintenance stages at 24 months. However, a Cochrane systematic review by Mastellos et al.¹⁵ noted that while Stages of Change-based interventions produced positive changes in dietary habits and physical activity, evidence for sustainable weight loss beyond one year remains inconclusive. These findings suggest that a 12-week program, as implemented in the present study, may be sufficient to initiate stage progression and improve knowledge and body composition, but a

longer intervention duration and extended follow-up would be necessary to achieve and sustain broader behavioral, attitudinal, and anthropometric changes among overweight hospital personnel.

In addition, the significant reduction in body fat percentage suggests that the program was effective in improving body composition beyond the changes observed in the comparison group. Although the effect size was moderate, it reflects measurable physiological improvements resulting from behavioral changes in diet and physical activity. This result is consistent with the studies of Poonperm and Banchonhattakit¹⁶ and Mekpreedawong and Sarayuthpitak¹⁷, which reported significant reductions in body fat percentage following behavior modification interventions.

However, no statistically significant differences were found between groups in overall health behaviors ($F=1.396$, $p=0.242$, Partial $\eta^2=0.022$), attitudes toward health behavior modification ($F=1.700$, $p=0.197$, Partial $\eta^2=0.026$), or body mass index (BMI) ($F=2.329$, $p=0.132$, Partial $\eta^2=0.035$). Although the experimental group demonstrated improvements in mean scores and slight reductions in BMI after program participation, these changes were not statistically significant when pretest scores were controlled. This may suggest that behavioral and attitudinal changes, as well as BMI reduction, require a longer intervention period or more intensive strategies to produce significant between-group differences. These findings are in line with the studies of Sridawruang et al.¹⁸, Thipkratok and Phatisena¹⁹, and Samart and Sota²⁰, which found that although improvements occurred after intervention, the differences were not always statistically significant when compared between groups.

Interestingly, the study found a significant reduction in body fat percentage ($p=0.015$) despite no significant change in BMI ($p=0.132$). This discrepancy may be attributed to the nature of the physical activity intervention, which likely promoted muscle maintenance or growth while reducing fat mass. Since muscle is denser than fat, BMI (which is based solely on weight) may not sensitively reflect positive changes in body composition over a short duration.

Despite the positive findings, several limitations of this study should be acknowledged. The relatively short duration of the intervention may not have been sufficient to capture long-term changes in health behaviors, attitudes, and anthropometric outcomes such as body mass index. In addition, the study was conducted among a specific group of hospital personnel, which may have limited the generalizability of the findings to other populations with different characteristics. Future studies should consider extending the follow-up period to evaluate the sustainability of behavior change and its long-term effects on health

outcomes. Furthermore, the health behavior modification program should be adapted and applied to other populations experiencing overweight, such as school-aged children, adolescents, older adults, and individuals with chronic diseases, in order to assess its broader applicability and effectiveness across diverse groups.

Conclusions

After controlling for baseline differences using ANCOVA, the experimental group demonstrated statistically significant improvements in knowledge and understanding regarding health behavior modification ($p < 0.001$) and body fat percentage ($p < 0.05$) compared with the comparison group. However, no significant between-group differences were found in overall health behaviors, attitudes toward health behavior modification, or body mass index (BMI) ($p > 0.05$). These findings suggest that the program was particularly effective in improving cognitive outcomes and certain aspects of physical health, while longer-term or more intensive interventions may be necessary to achieve broader behavioral and anthropometric changes.

Ethical Approval

The study was approved by the Institutional Human Research Ethics Committee of Ubon Ratchathani Rajabhat University (protocol code HE662079; approval date: 26 March 2024). Informed consent was obtained from all participants or their legal representatives.

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บทความวิจัย

ผลของโปรแกรมปรับเปลี่ยนพฤติกรรมสุขภาพโดยประยุกต์ใช้ทฤษฎีขั้นตอนการเปลี่ยนแปลงพฤติกรรมในบุคลากรสาธารณสุขที่มีภาวะน้ำหนักเกินในโรงพยาบาลอำนาจเจริญ

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บทคัดย่อ

ภาวะน้ำหนักเกินและโรคอ้วนเป็นปัญหาสาธารณสุขสำคัญที่นำไปสู่โรคไม่ติดต่อเรื้อรังและภาวะแทรกซ้อนต่าง ๆ ในทุกกลุ่มประชากร โดยเฉพาะในบุคลากรสาธารณสุขซึ่งมีบทบาทสำคัญในการส่งเสริมสุขภาพ หากสามารถดูแลสุขภาพของตนเองได้อย่างเหมาะสม ย่อมส่งผลดีต่อความน่าเชื่อถือในการให้คำปรึกษาแก่ประชาชน การวิจัยกึ่งทดลองนี้มีวัตถุประสงค์เพื่อศึกษาผลของโปรแกรมปรับเปลี่ยนพฤติกรรมสุขภาพที่ประยุกต์ใช้ทฤษฎีขั้นตอนการเปลี่ยนแปลงพฤติกรรม (Stages of change theory) ในบุคลากรที่มีภาวะน้ำหนักเกินของโรงพยาบาลอำนาจเจริญ กลุ่มตัวอย่างประกอบด้วยบุคลากรที่มีภาวะน้ำหนักเกิน ($BMI \geq 23$ กก./ม²) จำนวน 70 คน แบ่งเป็นกลุ่มทดลองและกลุ่มควบคุมกลุ่มละ 35 คน โดยกลุ่มทดลองได้รับโปรแกรมปรับเปลี่ยนพฤติกรรมสุขภาพ 12 สัปดาห์ ซึ่งประกอบด้วยการสร้างความตระหนักรู้ เสริมแรง ฝึกทักษะควบคุมอาหาร และการออกกำลังกาย ตลอดจนการติดตามและให้ข้อมูลย้อนกลับ ขณะที่กลุ่มควบคุมได้รับการดูแลตามปกติ เครื่องมือวิจัยประกอบด้วย โปรแกรมที่ผ่านการตรวจสอบความตรงเชิงเนื้อหาและแบบสอบถามที่มีค่าความเชื่อมั่น 0.76 วิเคราะห์ข้อมูลด้วยสถิติเชิงพรรณนา ได้แก่ ค่าร้อยละ ค่าเฉลี่ย และส่วนเบี่ยงเบนมาตรฐาน และใช้การวิเคราะห์ความแปรปรวนร่วม (ANCOVA) เพื่อเปรียบเทียบผลระหว่างกลุ่ม โดยกำหนดระดับนัยสำคัญทางสถิติที่ 0.05 ผลการศึกษาพบว่า ภายหลังการเข้าร่วมโปรแกรมปรับเปลี่ยนพฤติกรรมสุขภาพ กลุ่มทดลองและกลุ่มเปรียบเทียบมีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติในด้านความรู้และความเข้าใจเกี่ยวกับการปรับเปลี่ยนพฤติกรรมสุขภาพ ($F(1, 64) = 17.415, p < 0.001, \eta^2 = 0.214$) และด้านเปอร์เซ็นต์ไขมันในร่างกาย ($F(1, 64) = 6.297, p = 0.015, \eta^2 = 0.090$) โดยกลุ่มทดลองมีแนวโน้มดีกว่ากลุ่มเปรียบเทียบ และไม่พบความแตกต่างอย่างมีนัยสำคัญทางสถิติในด้านพฤติกรรมสุขภาพ ($F(1, 64) = 1.396, p = 0.242$) ทักษะการปรับเปลี่ยนพฤติกรรมสุขภาพ ($F(1, 64) = 1.700, p = 0.197$) และดัชนีมวลกาย ($F(1, 64) = 2.329, p = 0.132$) สรุปได้ว่า โปรแกรมที่ประยุกต์ใช้ทฤษฎีขั้นตอนการเปลี่ยนแปลงพฤติกรรมมีประสิทธิภาพในการเพิ่มพูนความรู้และลดเปอร์เซ็นต์ไขมันในร่างกายของบุคลากรที่มีภาวะน้ำหนักเกิน แม้ยังไม่พบความแตกต่างในด้านพฤติกรรมสุขภาพ ทักษะ และดัชนีมวลกายในระยะเวลาศึกษา การศึกษานี้ชี้ให้เห็นถึงความเป็นไปได้ในการนำแนวทางดังกล่าวไปประยุกต์ใช้ในระบบส่งเสริมสุขภาพของสถานพยาบาล โดยเฉพาะการพัฒนาโปรแกรมดูแลสุขภาพบุคลากรภายในองค์กรอย่างเป็นระบบ ทั้งยังสนับสนุนให้มีการออกแบบนโยบายหรือแนวทางการปฏิบัติสำหรับสถานบริการสุขภาพให้ดำเนินโครงการส่งเสริมสุขภาพบุคลากรควบคู่กับการบริการประชาชน

CASE REPORT

Severe Masseter Muscle Rigidity Following Succinylcholine Administration in a Patient with Inconclusive Pharmacogenetic Results for Susceptibility to Malignant Hyperthermia: A Case Report

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KEYWORDS

masseter muscle rigidity; succinylcholine; malignant hyperthermia; RYR1 protein; CACNA1S protein; anesthesia

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ABSTRACT

Masseter muscle rigidity following succinylcholine is traditionally viewed as a potential early indicator of malignant hyperthermia (MH), although most adult cases remain isolated without systemic progression. We report a 50-year-old woman who developed immediate, severe bilateral masseter rigidity after succinylcholine during induction of general anesthesia. Despite profound limitation in mouth opening of approximately 1.5 cm, videolaryngoscopic intubation was achieved on the first attempt, and mask ventilation remained uncomplicated. The rigidity persisted even after administration of cisatracurium, yet the patient demonstrated no systemic signs of MH, with normal hemodynamics, end-tidal CO₂, temperature, and laboratory values. Surgery was cancelled, and the rigidity gradually resolved during recovery in the intensive care unit. Targeted genetic testing for RYR1 and CACNA1S variants did not identify pathogenic mutations. However, given the limited scope of the tested variants, the result was considered inconclusive for determining MH susceptibility. This case illustrates that marked succinylcholine-induced masseter rigidity can occur without progression to systemic MH. It also highlights that nondiagnostic targeted genetic testing reflects current limitations in variant detection and should not be interpreted as definitively excluding susceptibility. In patients presenting with significant isolated masseter rigidity, continued MH preparedness remains warranted despite the absence of systemic manifestations during the initial event.

Introduction

Masseter muscle rigidity (MMR) following administration of succinylcholine is a recognized but rare event in adults; pediatric data suggest incidences below 1% (approximately 0.3% in selected series)^{1,2}. Because MMR has historically been considered a potential early indicator of MH¹⁻⁵, its occurrence warrants prompt assessment and perioperative vigilance^{2,4,5}. However, the majority of isolated MMR episodes do not progress to fulminant MH, especially in adult individuals, creating diagnostic uncertainty and complicating perioperative decision-making regarding future anesthetic techniques^{1,2,5}.

The increasing availability of genetic testing has added complexity to the evaluation of suspected MH. Although pathogenic variants in RYR1 and CACNA1S are strongly associated with MH susceptibility, current genetic testing approaches have limited sensitivity, and a substantial proportion of clinically susceptible individuals may not harbor identifiable pathogenic variants⁶⁻⁹. Most data regarding the diagnostic yield of genetic testing derive from broader MH-susceptible cohorts rather than from patients presenting specifically with succinylcholine-induced

masseter muscle rigidity. Nevertheless, because MMR may represent an early manifestation of MH in some cases, the limitations of genetic testing in MH populations are also relevant when interpreting such presentations. Therefore, nondiagnostic genetic findings must be interpreted in conjunction with clinical presentation rather than relied upon in isolation^{6,7}.

Here, we describe an adult patient who developed severe, isolated masseter rigidity immediately after succinylcholine administration, with persistent jaw stiffness despite nondepolarizing neuromuscular blockade but without systemic MH manifestations. The diagnostic ambiguity was further heightened by targeted pharmacogenetic testing that yielded an uncertain susceptibility classification. This case highlights the challenges in interpreting isolated MMR events, the limitations of limited-panel genetic testing, and the importance of maintaining MH precautions even when systemic features are absent.

Case report

This case report describes a 50-year-old woman (weight 57.5 kg, height 150.7 cm, BMI 25.3 kg/m²) with a history of

rheumatic mitral disease status post mechanical mitral valve replacement in 2014 and chronic atrial fibrillation, who was scheduled for elective extraction of an impacted mandibular molar. She was anticoagulated with warfarin and underwent perioperative bridging as recommended by the cardiology team. Preoperative transthoracic echocardiography demonstrated normal left ventricular systolic function (ejection fraction 67%) and a normally functioning mechanical mitral valve, with mild tricuspid regurgitation. Electrocardiography showed atrial fibrillation with nonspecific T-wave abnormalities, and chest radiography revealed mild cardiomegaly without pulmonary congestion. Airway examination was unremarkable, and the patient reported an uneventful previous general anesthetic in 2014 in which succinylcholine had not been administered. She reported no history of herbal medication use, substance abuse, or occupational exposure relevant to neuromuscular disorders.

In the operating room, standard monitoring was applied. Baseline vital signs were heart rate 64 beats/min, blood pressure 102/61 mmHg, SpO₂ 100%, and core temperature 36.1°C. After preoxygenation with 100% oxygen, anesthesia was induced with fentanyl 75 µg and propofol 100 mg, followed by succinylcholine 75 mg for neuromuscular relaxation. Immediately after fasciculations subsided, the anesthesiologist noted marked resistance to mouth opening using a cross-finger technique. Severe bilateral masseter muscle rigidity (MMR) was evident, and a second anesthesiologist was called to assist. Mask ventilation remained easy, with normal chest rise and an end-tidal CO₂ of 30–32 mmHg.

Videolaryngoscopic intubation was attempted and achieved on the first attempt with a Cormack–Lehane grade of 2, using a 7.0-mm oral RAE tube. Forced mouth opening was limited to approximately 1.5 cm. After intubation, MMR persisted, and attempts by the maxillofacial surgeon to open the mouth using a retractor were unsuccessful. Cisatracurium 8 mg was administered; however, jaw stiffness remained unchanged. A rolled-gauze bite block was carefully inserted to protect the endotracheal tube.

Given concern for an early presentation of MH, the team avoided volatile anesthetics, maintained anesthesia with propofol target-controlled infusion (3 µg/mL), flushed the circuit with high-flow oxygen/air (FiO₂ 0.5),

and inserted a radial arterial catheter. Arterial blood gases, serum electrolytes, creatine kinase (81 U/L), and temperature remained within acceptable limits. No tachycardia, hypercarbia, hyperthermia, generalized rigidity, or myoglobinuria occurred. Despite these reassuring findings, severe MMR persisted throughout the time in the operating room, lasting approximately two hours, and did not improve after administration of cisatracurium. The surgery was cancelled, and the patient was transferred intubated to the surgical intensive care unit (ICU) with dantrolene prepared but not administered.

Upon ICU arrival, propofol infusion was discontinued, and the patient became fully awake approximately 30 minutes later. Masseter muscle tone gradually returned to normal as consciousness improved, marking the first time the rigidity had resolved since succinylcholine administration. The patient was extubated two hours after ICU admission following a pressure-support trial (PS 5 cmH₂O, PEEP 5 cmH₂O). She was monitored in the ICU for 24 hours, during which no recurrent muscle rigidity, hemodynamic instability, or biochemical abnormalities were observed. She was then transferred to the general ward to resume anticoagulation therapy and undergo serial coagulation testing until the international normalized ratio reached the therapeutic target. She was discharged thereafter without complications, and the remainder of her hospitalization was unremarkable.

Targeted genetic testing for RYR1 (rs1801086, rs193922764, rs121918594) and CACNA1S (rs772226819) was performed at a certified molecular laboratory. All tested loci demonstrated homozygous wild-type genotypes. The accompanying report stated that these findings were not sufficient to determine MH susceptibility.

The patient was informed in detail about the intraoperative event and its possible implications. The findings were documented in her medical record, and she was provided with a malignant hyperthermia alert card. She was advised to avoid triggering agents, including volatile anesthetics and succinylcholine, in future procedures unless definitive diagnostic evaluation becomes available.

Table 1 summarizes the sequence of perioperative events, including the onset and persistence of masseter muscle rigidity, intraoperative management decisions, postoperative course, and subsequent genetic testing results.

Table 1 Chronological timeline of clinical events

Time Point	Clinical Event	Key Findings / Actions
Preoperative	Routine evaluation	Stable cardiac status; airway examination unremarkable
Induction	Succinylcholine 75 mg administered	Fasciculations observed
Immediately after fasciculations	Severe bilateral masseter muscle rigidity	Marked resistance to mouth opening (~1.5 cm)
Airway management	Videolaryngoscopic intubation	Successful on first attempt; mask ventilation remained easy
Post-intubation	Persistent MMR despite cisatracurium 8 mg	No improvement in jaw stiffness
Intraoperative period (~2 hours)	Non-triggering anesthetic maintained	Normal ETCO ₂ , temperature, CK; no systemic MH features

Table 1 Continued

Time Point	Clinical Event	Key Findings / Actions
End of procedure	Surgery cancelled	Transferred intubated to ICU; dantrolene prepared but not administered
ICU (30 minutes)	Propofol discontinued	Patient awake; rigidity resolved as consciousness returned
ICU (2 hours)	Extubation	Successful after pressure support trial
24 hours post-event	Observation	No recurrence of rigidity or biochemical abnormalities
Post-discharge	Genetic testing	No pathogenic variants; result inconclusive for MH susceptibility

Discussion

In this patient, the most striking feature was the severity and persistence of MMR immediately after succinylcholine administration, despite preserved ventilation and the absence of systemic MH features. Despite complete neuromuscular blockade with cisatracurium, the masseter muscles remained visibly and palpably rigid, with no improvement in mouth opening, and both anesthesiologists and the maxillofacial surgeon were unable to achieve adequate mouth opening, underscoring the magnitude of the localized response. Nevertheless, serial assessments—including end-tidal CO₂, core temperature, arterial blood gas analysis, electrolyte profile, and creatine kinase level—remained within normal limits throughout her intraoperative and intensive care course, making fulminant MH unlikely in this episode. This presentation is consistent with prior reports describing isolated MMR without progression to systemic MH in the adult population^{1,2,4,5}.

The mechanism of succinylcholine-induced MMR remains incompletely understood. Proposed explanations include exaggerated sarcoplasmic calcium release in masseter muscle fibers, transient dysfunction of the RYR1 calcium-release channel, or an acute localized contracture response that does not progress to systemic hypermetabolic activation¹⁰. This mechanistic overlap with MH physiology contributes to the diagnostic uncertainty surrounding isolated MMR.

Although targeted pharmacogenetic analysis of RYR1 and CACNA1S did not identify any pathogenic variants, the laboratory classified the overall result as “uncertain susceptibility.” This designation reflects the limited scope of the East Asian variant panel used and highlights the well-recognized limitation that negative findings on targeted testing do not exclude MH susceptibility^{6–8}. It is also important to consider ethnic background when interpreting genetic results. The patient in this case is of Thai ethnicity, and the frequency and spectrum of RYR1 and CACNA1S variants may differ across populations^{6,9}. Targeted panels developed based on variants more commonly reported in Western cohorts may therefore have reduced diagnostic yield in other ethnic groups, further contributing to inconclusive findings^{6,7,12}. Current European Malignant Hyperthermia Group (EMHG)⁷ and Clinical Pharmacogenetics Implementation Consortium (CPIC)¹² guidance similarly notes that only a subset of

pathogenic variants is detectable with such focused assays, and a substantial proportion of clinically susceptible individuals may exhibit no identifiable mutation even with broader sequencing^{6–9,12,13}. This reflects current guidance from the EMHG and CPIC, which state that genetic testing alone cannot exclude MH susceptibility. Only 30–50% of MH-susceptible individuals have identifiable pathogenic variants, even when full sequencing is used^{6–9}. Furthermore, targeted panel testing captures only a minority of established MH-associated variants^{6,7}. Consistent with these limitations, the pharmacogenomics report specifically advised cautious interpretation and clinical correlation.

Given the severity of MMR and the absence of systemic MH signs, the patient was immediately managed as potentially MH-susceptible based on clinical presentation alone, consistent with current recommendations^{1,2,4,5,7,11,13}. The subsequent genetic testing results, although nondiagnostic, did not alter the clinical classification. Isolated succinylcholine-induced MMR remains a meaningful perioperative warning sign, and MH preparedness is required even when systemic manifestations do not develop^{1,2,4,5,12–15}. For her future surgery, a non-triggering anesthetic technique—monitored anesthesia care with extensive local anesthetic infiltration—was selected as the safest strategy for individuals with possible but unconfirmed MH susceptibility^{6–8,12–15}.

Conclusion

This case underscores the challenges in interpreting isolated MMR when systemic MH features are absent and when pharmacogenetic testing provides nondiagnostic results. Until more comprehensive diagnostic tools such as *in vitro* contracture testing or whole-gene sequencing become widely available, clinicians should interpret isolated MMR conservatively, recognize the diagnostic limitations of limited-panel genetic assays, and tailor anesthetic management to balance clinical safety with the residual uncertainty intrinsic to current MH diagnostics.

Informed Consent

Written informed consent for publication was obtained from the patient on 13 November 2025, and all identifying information was anonymized to protect patient confidentiality.

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บทความรายงานผู้ป่วย

ภาวะกล้ามเนื้อแมสซีเตอร์หดเกร็งรุนแรงภายหลังได้รับซัคซินิลโคลีนในผู้ป่วยที่มีผลการตรวจทางเภสัชพันธุศาสตร์ไม่ชัดเจนต่อความไวต่อภาวะ malignant hyperthermia: รายงานผู้ป่วย

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คำสำคัญ

กล้ามเนื้อแมสซีเตอร์หดเกร็ง; ซัคซินิลโคลีน; ภาวะกล้ามเนื้อทึบเปอร์เธอร์เมีย; โพรตีน RYR1; โพรตีน CACNA1S; การระบุความเสี่ยง

บทคัดย่อ

ภาวะกล้ามเนื้อแมสซีเตอร์หดเกร็งหลังได้รับซัคซินิลโคลีนมักถูกมองว่าเป็นสัญญาณเริ่มต้นที่อาจบ่งชี้ถึงภาวะ malignant hyperthermia (MH) อย่างไรก็ตาม ในผู้ป่วยส่วนใหญ่เหตุการณ์ดังกล่าวมักเกิดขึ้นแบบเฉียบพลันโดยไม่ถูกมองว่าเป็นความผิดปกติของระบบทั่วร่างกาย รายงานฉบับนี้นำเสนอผู้ป่วยหญิงอายุ 50 ปี ซึ่งเกิดอาการหดเกร็งของกล้ามเนื้อแมสซีเตอร์อย่างรุนแรงทั้งสองข้างทันทีหลังได้รับซัคซินิลโคลีนระหว่างนำสลบ วิสัญญีแพทย์สามารถช่วยหายใจด้วยหน้ากากได้โดยไม่ยากลำบาก แม้สามารถเปิดปากได้เพียง 1.5 เซนติเมตร แต่ยังคงสามารถใส่ท่อหายใจด้วยวิดีโอลาริงโกสโคปได้สำเร็จ ตั้งแต่ครั้งแรก อาการเกร็งคงอยู่แม้ได้รับยาหย่อนกล้ามเนื้อซัสอาทราคิวรีมเพิ่มเติม ผู้ป่วยไม่มีอาการแสดงทางคลินิกอื่นของ MH เช่น ความดันโลหิตผิดปกติ หัวใจเต้นเร็ว คาร์บอนไดออกไซด์ปลายลมหายใจสูงขึ้น อุณหภูมิร่างกายเพิ่มขึ้น หรือความผิดปกติทางห้องปฏิบัติการ การผ่าตัดถูกยกเลิก และอาการเกร็งค่อย ๆ ทุเลาลงระหว่างพักฟื้น ในห้องผู้ป่วยวิกฤต ผลการตรวจยีนแบบจำเพาะต่อ RYR1 และ CACNA1S ไม่พบการกลายพันธุ์ที่ก่อโรค อย่างไรก็ตาม เนื่องจากการตรวจครอบคลุมเพียงตำแหน่งการกลายพันธุ์บางส่วน ผลดังกล่าวจึงไม่สามารถใช้สรุปความไวต่อ MH ได้อย่างแน่ชัด รายงานนี้สะท้อนว่าอาการเกร็งของกล้ามเนื้อแมสซีเตอร์ที่รุนแรงจากซัคซินิลโคลีนอาจเกิดขึ้นได้โดยไม่ถูกมองเป็น MH แบบ systemic และผลการตรวจยีนที่ไม่สามารถสรุปได้ควรตีความอย่างระมัดระวัง เนื่องจากสะท้อนข้อจำกัดของการตรวจทางพันธุกรรมในปัจจุบันมากกว่าจะใช้ตัดสินความเสี่ยงต่อ MH ได้อย่างเด็ดขาด ดังนั้น ผู้ป่วยที่มีภาวะ isolated masseter muscle rigidity ควรได้รับการเตรียมความพร้อมรับภาวะ MH ในการดูแลครั้งต่อไป แม้ไม่พบอาการระบบในเหตุการณ์ครั้งนี้

ผู้นิพนธ์ประสานงาน

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CASE REPORT

Successful Reconstruction of Post-Hepatectomy Bile Duct Injury Using Magnetic Compression Anastomosis: A Case Report

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KEYWORDS

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ABSTRACT

Iatrogenic bile duct injuries (BDI) following hepatectomy represent a serious and potentially life-threatening complication. Magnetic compression anastomosis (MCA) is an emerging minimally invasive technique that can restore biliary continuity when conventional endoscopic or percutaneous methods fail. We report the case of a 68-year-old man with a history of sigmoid colon cancer and liver metastases underwent right hepatectomy with wedge resection of segment 4a. Postoperatively, he developed persistent jaundice. Imaging demonstrated left intrahepatic duct dilatation with abrupt narrowing at the hepatic confluence. Percutaneous transhepatic biliary drainage (PTBD) was established; however, guidewire cannulation via both ERCP and PTBD failed due to complete biliary obstruction. The patient subsequently underwent MCA. The magnets approximated across the stenosis, creating a neo-anastomosis. After successful biliary recanalization and stenting were achieved. At the six-month follow-up, the patient remained clinically stable with normal liver function. In conclusion, this case demonstrates the feasibility and clinical success of MCA for biliary reconstruction following iatrogenic bile duct injury post-hepatectomy. MCA offers a safe, effective, and less invasive alternative to surgical reconstruction.

Introduction

Iatrogenic bile duct injuries (BDI) following hepatectomy represent a serious and potentially life-threatening complication, often associated with complex biliary anatomy, prior interventions, or intraoperative trauma¹⁻³. Effective management requires a multidisciplinary approach within specialized hepatobiliary centers, with treatment goals focused on controlling biliary sepsis, restoring ductal continuity, and preserving hepatic function.

Endoscopic management, including balloon dilatation and sequential stenting, is typically effective for partial or non-complex strictures. In more challenging cases, percutaneous transhepatic biliary drainage (PTBD) may serve as an adjunct or alternative. However, when complete biliary obstruction precludes guidewire passage, surgical reconstruction becomes necessary. Despite being the standard of care in such scenarios, surgery is associated with considerable morbidity and mortality, particularly in patients with altered anatomy or poor physiological reserve.

To address these limitations, magnetic compression anastomosis (MCA) has emerged as a novel, minimally invasive technique that enables internal biliary drainage by creating a neo-anastomosis through gradual pressure-induced necrosis between two magnets placed via endoscopic and percutaneous routes⁴⁻⁶.

Herein, we report a case of successful biliary tract reconstruction using MCA in a patient with iatrogenic bile duct injury following right hepatectomy, highlighting the feasibility and clinical applicability of this technique in managing complex biliary injuries.

Case report

Chief complaints

Persistent jaundice following right hepatectomy.

History of present illness

A 68-year-old man with a history of diabetes mellitus, hypertension, and coronary artery disease was initially diagnosed with sigmoid colon cancer with synchronous liver metastases. In 2022, he underwent laparoscopic sigmoidectomy and intraoperative microwave ablation of five hepatic lesions. He subsequently received adjuvant chemotherapy with oxaliplatin and capecitabine. In 2024, routine surveillance with contrast-enhanced computed tomography (CT) revealed new hepatic metastases in segments 5/6 (measuring 3.7 cm) and segment 4 (1.5 cm), while the previously ablated sites remained stable. The patient subsequently underwent a right hepatectomy with wedge resection of segment 4a. During the right

hepatectomy, the right hepatic duct was identified and divided at the hilum using suture ligation with Vicryl 3-0. Special care was taken to avoid the left hepatic duct; however, the hilar dissection was challenging due to adhesions from previous microwave ablation.

On postoperative day 3, the patient developed clinically apparent and persistent obstructive jaundice, indicative of an acute post-surgical injury rather than a delayed fibrotic stricture. Laboratory investigations confirmed the obstruction, showing elevated levels of total bilirubin (TB) at 11.0 mg/dL, direct bilirubin (DB) at 10.2 mg/dL, and alkaline phosphatase (ALP) at 297 IU/L. Follow-up computed tomography (CT) imaging

revealed postoperative changes consistent with a prior right hepatectomy. Notably, there was marked dilatation of the left intrahepatic bile ducts, with an abrupt cutoff at the hepatic duct confluence, indicative of high-grade biliary obstruction (Figure 1). A percutaneous transhepatic biliary drainage (PTBD) catheter was inserted into the left intrahepatic duct; however, guidewire cannulation of the distal bile duct via the PTBD tract was unsuccessful. Subsequent percutaneous transhepatic cholangiography (PTC) demonstrated significant dilatation of the left intrahepatic bile ducts with complete obstruction at the level of the hepatic duct confluence (Figure 2).



Figure 1 Axial contrast-enhanced CT showing left intrahepatic duct dilatation with abrupt cutoff at the hepatic duct confluence following right hepatectomy.



Figure 2 Percutaneous transhepatic cholangiography shows dilated left intrahepatic ducts with complete obstruction at the hepatic duct confluence

Physical examination

The initial assessment indicated that the patient's vital signs were within normal limits. He appeared clinically stable, though visible jaundice was noted. Cardiopulmonary examination revealed no abnormalities.

Abdominal examination demonstrated a well-healed surgical scar consistent with previous laparoscopic

sigmoidectomy and right hepatectomy. A percutaneous transhepatic biliary drainage (PTBD) catheter was observed exiting through the right upper quadrant of the abdominal wall. The abdomen was flat and soft, with no tenderness, guarding, or signs of peritoneal irritation. No shifting dullness was detected.

Treatment

Subsequent endoscopic retrograde cholangiopancreatography (ERCP) was performed in an attempt to traverse the biliary stricture with a guidewire, but the procedure was unsuccessful due to complete obstruction at the level of the biliary confluence. Cholangiographic imaging revealed a biliary stricture with an estimated gap of approximately 1 mm. Given the failure of standard ERCP-guided stenting and the inability to access the proximal duct, the multidisciplinary team elected to proceed with magnetic compression anastomosis (MCA) as an alternative method to restore biliary continuity.

In preparation for MCA, the existing percutaneous transhepatic biliary drainage (PTBD) tract was gradually dilated to 10 French over 1–2 weeks to facilitate the insertion of the magnet. This step was essential to ensure smooth insertion and passage of the magnet through the established entry tract during the procedure. Custom-made, gold-plated neodymium magnets measuring 3 mm in diameter were used. The magnet delivery system utilized a 10-French stent pusher, which was modified by creating a hole at its tip using a surgical blade to allow guidewire cannulation (Figure 3).



Figure 3 Magnet delivery system. The daughter magnet is delivered via PTBD and the parent magnet via ERCP. A side hole on the pusher (black arrow) allows guidewire cannulation.

A parent magnet was delivered endoscopically through a side-viewing duodenoscope and positioned distal to the site of obstruction, just proximal to the ampulla of Vater. Simultaneously, a daughter magnet was inserted percutaneously via the left-sided PTBD tract and

advanced under fluoroscopic guidance to the proximal end of the obstruction within the left intrahepatic duct. Under continuous fluoroscopic monitoring, magnetic attraction brought the two magnets into alignment across the fibrotic segment (Figure 4).

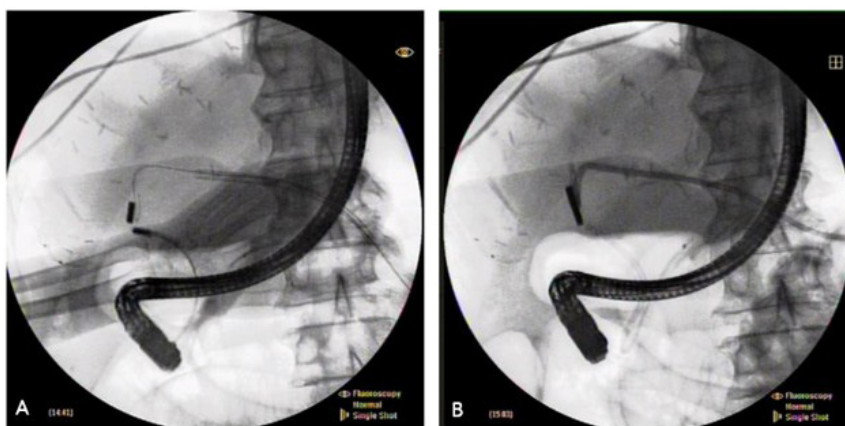


Figure 4 Fluoroscopic cholangiogram showing (A) Parent and daughter magnets positioned via ERCP and PTBD. (B) Magnet alignment across the stricture, enabling fistula formation.

This configuration allowed for the gradual compression of the intervening fibrotic tissue between the magnets, facilitating necrosis and the eventual formation of a neo-anastomosis. During this period, external biliary drainage was maintained via the PTBD catheter to prevent bile accumulation.

Three weeks after magnet placement, both magnets passed spontaneously into the gastrointestinal tract and were expelled without incident. Following this, a guidewire was successfully advanced through the newly formed tract, confirming the establishment of a continuous channel (Figure 5A). The tract was then dilated using a standard biliary dilator, and an internal plastic stent was deployed via ERCP to maintain patency of the reconstructed duct.

Outcome and follow up

Following successful internal drainage and stent placement, the percutaneous transhepatic biliary drainage (PTBD) catheter was removed. The patient's clinical status improved markedly, with progressive resolution of jaundice.

One month after stent placement, laboratory investigations demonstrated a significant reduction in cholestatic parameters, with total bilirubin decreasing to 1.61 mg/dL and direct bilirubin to 1.29 mg/dL. At the three-month follow-up, endoscopic retrograde cholangiopancreatography (ERCP) was performed, and the internal plastic stent was replaced with a fully covered self-expandable metal stent (FCSEMS) to ensure long-term ductal patency (Figure 5B). At six months, the patient remained clinically stable, with normal liver function tests and no radiologic or clinical evidence of recurrent biliary obstruction.

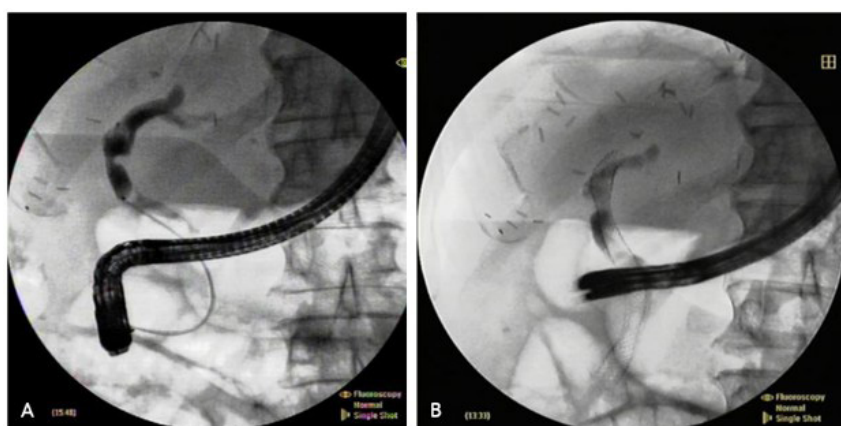


Figure 5 Fluoroscopic cholangiogram showing (A) Successful ductal recanalization 3 weeks post-MCA. (B) a fully covered self-expandable metal stent (FCSEMS) placement.

Discussion

Iatrogenic bile duct injuries (BDI) following hepatectomy have been reported in 3.6% to 17% of cases¹⁻³. These injuries, particularly when involving complete transection or severe strictures, pose considerable management challenges. When endoscopic approaches such as stenting fail, surgical biliary reconstruction remains the standard of care. However, this intervention is associated with significant morbidity and mortality, with reported complication rates ranging from 16% to as high as 39%, especially in patients with complex biliary anatomy or multiple comorbidities^{1,2}.

Magnetic compression anastomosis (MCA) has emerged as a promising minimally invasive alternative for patients with refractory biliary strictures⁴⁻⁶. The technique involves placing magnets at both ends of the occluded duct to induce pressure necrosis and form a neo-anastomosis. MCA has been most commonly reported in biliary strictures following liver transplantation or cholecystectomy⁵⁻¹⁷. The application of MCA in BDI after hepatectomy remains relatively underreported¹⁸⁻²⁰. The present case adds to this limited body of evidence and supports MCA as a feasible and effective alternative in this subgroup.

The literature indicates that MCA achieves technical success in 70% to 100% of cases, with durable long-term

patency⁵⁻¹⁹. Compared to surgical reconstruction, MCA has demonstrated benefits including reduced complication rates, shorter hospital stays, and avoidance of reoperation, particularly in elderly or high-risk patients^{13,21}.

One the key factor influencing the success of magnetic compression anastomosis (MCA) is the inter-ductal distance between the proximal and distal bile ducts. Comprehensive preprocedural imaging using MRCP, ERCP, or percutaneous transhepatic cholangiography is crucial for assessing anatomical feasibility and ensuring appropriate case selection^{13,21}.

The surgical technique used during the initial hepatectomy can significantly influence the success of MCA. In this case, the use of suture ligation near the biliary confluence likely resulted in a complete, short-segment occlusion (approximately 1 mm), which is ideal for magnetic attraction¹¹. Furthermore, the timing of MCA intervention is critical. We initiated the procedure two weeks after the injury. Addressing the stricture in the subacute phase, after the initial postoperative inflammatory response had subsided yet before dense chronic fibrosis could develop, likely facilitated easier magnet alignment and more rapid fistula formation compared to long-standing chronic strictures¹¹.

The efficacy of magnetic coupling diminishes significantly when the inter-ductal distance exceeds 10–15

mm⁵⁻¹⁹. Nonetheless, technical innovations, such as serial magnet alignment, have extended this limit to up to 20 mm in selected cases¹². In our case, favorable ductal alignment and a short stricture length facilitated successful magnet approximation and fistula formation.

Recanalization time is highly variable, influenced by multiple factors including stricture length, ductal shape, magnetic force, alignment pattern of the magnets, and the anatomical axis of the bile duct.¹⁰⁻¹³ The reported duration in the literature ranges from 2 to 50 days⁵⁻¹⁹. The researchers opted for a 3-week interval, as supported by previous studies⁸, though follow-up imaging revealed earlier recanalization. This observation underscores the need for further research to better predict optimal recanalization timing and guide follow-up protocols.

For long-term outcomes, MCA appears to outperform conventional ERCP-based treatments. Li et al. reported a recurrence rate of 3.9% post-MCA, substantially lower than the 3–37.5% range seen with ERCP. This may be attributed to MCA's mechanism of action, which mimics surgical resection by inducing ischemic necrosis of the stricture, potentially lowering restenosis risk¹³. To maintain fistula patency, most authors recommend stent placement for 6–12 months post-recanalization, using either plastic or fully covered self-expandable metal stents (FCSEMS)^{10,11,13}. Nonetheless, optimal stenting duration is yet to be defined.

When conventional ERCP fail, endoscopic ultrasound guided hepatogastrostomy (EUS-HGS) is a common alternative^{20,22,23}. Although direct comparative studies are lacking for rare bile duct injuries following hepatectomy, MCA offers a distinct anatomical advantage. While the ultrasound guided bypass provides effective drainage, it requires permanent stenting and bypasses the sphincter of Oddi. Furthermore, a recent meta regression analysis highlights adverse events for this bypass, including cholangitis, sepsis, bleeding, biliary leakage, pneumoperitoneum, and stent migration²². In contrast, MCA creates a neo anastomosis that restores natural physiological biliary continuity, making it preferable for a physiological long-term reconstruction. Notably, current clinical trends suggest that EUS-HGS is increasingly utilized as a preferred access route to deliver magnets instead of PTBD, thereby eliminating the need for an external drainage catheter and improving patient comfort^{20,23}.

Although promising, MCA is not without risks. Misalignment, magnet migration, or inadequate tissue necrosis may result in failed fistula formation, false lumen creation, bile leakage, or retained magnets within the intrahepatic bile ducts^{5,6,15}. Some reports have described cases of cholangitis and biliary bleeding due to entrapment of blood vessels between the magnets^{13,21}. Furthermore, the technique requires close interdisciplinary collaboration among interventional radiologists, endoscopists, and hepatobiliary surgeons, underscoring the importance of institutional experience and the availability of specialized expertise to ensure procedural success and minimize risks.

Conclusions

In conclusion, this case reinforces MCA as a valuable salvage technique for complex post-hepatectomy biliary injuries. When performed in appropriate candidates with careful anatomical evaluation and coordinated multidisciplinary care, MCA offers a less invasive yet effective alternative to surgical reconstruction.

Informed Consent

Written informed consent for publication was obtained from the patient on 4 September 2025, and all identifying information was anonymized to protect patient confidentiality.

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บทความรายงานผู้ป่วย

การซ่อมแซมท่อน้ำดีที่ได้รับบาดเจ็บภายหลังการผ่าตัดตับโดยใช้เทคนิคการเชื่อมต่อท่อน้ำดีด้วยแรงกดจากแม่เหล็ก: รายงานผู้ป่วย

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บทคัดย่อ

การบาดเจ็บของท่อน้ำดีจากการผ่าตัดโดยไม่ได้ตั้งใจหลังการผ่าตัดตับ ถือเป็นภาวะแทรกซ้อนที่รุนแรง และอาจเป็นอันตรายถึงชีวิต เทคนิคการประสานท่อน้ำดีด้วยแม่เหล็ก เป็นวิธีการใหม่ที่มีการรุกรานต่ำ ช่วยสามารถซ่อมแซมท่อน้ำดีได้ ในกรณีที่วิธีการส่องกล้อง หรือการใส่สายระบายผ่านผิวหนังแบบปกติไม่สามารถซ่อมแซมได้ รายงานนี้ได้นำเสนอผู้ป่วยชายอายุ 68 ปี มีประวัติเป็นมะเร็งลำไส้ใหญ่ และพบว่ามีภาวะแพร่กระจายของโรคไปยังตับ จึงได้ทำการผ่าตัดเอาส่วนของตับด้านขวาออก ร่วมกับการตัดตับบริเวณส่วนที่ 4a ออก ภายหลังการผ่าตัดพบว่า ผู้ป่วยมีอาการตัวเหลืองตาเหลืองจากการตรวจเครื่องเอกซเรย์คอมพิวเตอร์ พบว่ามีการขยายตัวของท่อน้ำดีภายในตับด้านซ้ายร่วมกับการตีบแคบบริเวณจุดรวมของท่อน้ำดี จึงได้มีการใส่สายระบายน้ำดีผ่านผิวหนังเข้าสู่ตับด้านซ้าย แต่ไม่สามารถสอดลวดนำทางผ่านลงไปได้เนื่องจากมีการอุดตันของท่อน้ำดีอย่างสมบูรณ์ ผู้ป่วยจึงได้รับการรักษาด้วยเทคนิคการประสานท่อน้ำดีด้วยแม่เหล็ก โดยแม่เหล็กทั้งสองที่ตำแหน่งท่อน้ำดีแต่ละข้างจะเข้าประสานกันบริเวณตำแหน่งตีบแคบ ทำให้เกิดการสร้างทางเดินน้ำดีใหม่ หลังจากท่อน้ำดีเปิด จึงใส่ท่อระบายน้ำดีเพื่อค้ำยัน จากการติดตามผลต่อเนื่องครบ 6 เดือน ผู้ป่วยยังคงมีอาการคงที่ไม่มีภาวะแทรกซ้อน และผลการตรวจการทำงานของตับอยู่ในเกณฑ์ปกติ รายงานนี้แสดงให้เห็นถึงความเป็นไปได้และความสำเร็จทางคลินิกของเทคนิคการประสานท่อน้ำดีด้วยแม่เหล็ก ในการซ่อมแซมท่อน้ำดีที่ได้รับบาดเจ็บภายหลังการผ่าตัดตับ ซึ่งการใช้เทคนิคนี้เป็นทางเลือกที่ปลอดภัย มีประสิทธิภาพ และมีการรุกรานต่ำเมื่อเทียบกับการผ่าตัดซ่อมแซมแบบเปิดหน้าท้อง



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