*Original article*

# Evaluation of the appropriateness of preoperative tests on patients undergoing elective neurosurgery

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**Objective** To explore the costs and benefits of 10 preoperative tests ordered for patients undergoing elective neurosurgery including resulting changes in anesthetic or surgical plans.

**Methods** This prospective observational study of ten perioperative laboratory and radiologic tests was conducted with 344 adult patients who were scheduled for elective neurosurgery from April 2016 through March 2017. The study investigated tests ordered just prior to the surgery as well as those which had been conducted during the previous six months. The appropriateness of each test was determined based on the published guidelines of the American Society of Anesthesiologists (ASA) and the Royal College of Anesthesiologists of Thailand (RCAT). The financial costs of the tests were calculated and the patient benefits were analyzed.

**Results** Among the 344 patients in the study, more than 50% had undergone tests including complete blood count (CBC), blood urea nitrogen and creatinine (BUN&Cr), and electrolytes within the six months prior to their surgery. Based on ASA and RCAT guidelines, in only a small percentage of cases was there a medical reason to have those tests repeated. Less than 3% of the abnormal results found in the repeated tests required further management. The test most frequently ordered appropriately, i.e., following the ASA and RCAT guidelines, was CBC. The test which was least frequently ordered in cases where the guidelines indicated it should be done was blood sugar (BS). The two tests most frequently ordered in cases where the guidelines indicated they were not necessary were prothrombin time and partial thromboplastin time (PT&PTT), and calcium, magnesium and phosphate ($CaMgPO_4$). If all screening tests had been ordered following the ASA and RCAT guidelines, it would have resulted in a substantial reduction (up to 90%) in investigation fees for liver function test, $CaMgPO_4$ and PT&PTT.

**Conclusions** Preoperative investigations which are unnecessary according to ASA and RCAT guidelines are frequently ordered in our institute. A clearer understanding of the patterns of test ordering may help neurosurgeons determine which preoperative tests are appropriate and necessary. **Chiang Mai Medical Journal 2018;57(3):127-34.**

**Keywords:** test, preoperative, neurosurgery, routine

## Introduction

Preoperative evaluation, including clinical assessment and diagnostic workup, are necessary in patients with preexisting neurological conditions who are scheduled to undergo either

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non-neurological or neurosurgical procedures (1). However, over the past several decades, there has been an increase in routine preoperative laboratory tests and a concomitant reduction in clinical assessment. Routine tests as defined by the American Society of Anesthesiologists (ASA) are those done without any specific clinical indication or purpose. Examples of routine tests include blood tests, urine tests, chest radiography (CXR), and electrocardiography (ECG) (2,3). All tests should be patient-specific and should be based on patient history, physical examination findings, and the level of risk of the procedure (2–5). Performing routine screening tests in healthy patients provides minimal benefit in diagnosing diseases or in changing anesthetic practices (3). Retrospective reviews (6-8) have reported no adverse outcomes in cases where unnecessary preoperative testing, was eliminated (9). This study aimed to examine the appropriateness of ten preoperative tests commonly ordered by neurosurgeons at a university teaching hospital in northern Thailand.

## Methods

Following receipt of ethics approval from the Institutional Review Board of the Faculty of Medicine, Chiang Mai University, patients scheduled for elective neurosurgery during April 2016 through March 2017 were prospectively enrolled in the study. Patients under 18 years old and those with a Glasgow coma scale (GCS) score less than 9 were excluded, leaving a total of 344 adult patients in the study. We studied 10 preoperative screening tests including [1] Complete blood count (CBC), [2] Urine analysis (UA), [3] Blood urea nitrogen and creatinine (BUN&Cr), [4] Electrolytes, [5] Calcium, magnesium and phosphate ($CaMgPO_4$), [6] Blood sugar (BS), [7] Prothombin time and partial thomboplastin time (PT&PTT), [8] Liver function test (LFT), [9] Electrocardiography (ECG), and [10] Chest radiography (CXR). Both preoperative tests and tests which had been done within the previous 6 months were reviewed, i.e., tests done for the first time just prior to the operation and repeated tests which had been previously done within the six month period preceding the operation.

The attending resident caring for a patient recorded all preoperative tests that were done. For each of the ten tests, the resident noted whether ordering the test was in accordance with the published guidelines of the ASA (10) and the Royal College of Anesthesiologists of Thailand (RCAT) (11). Tests that were ordered in accordance with the guidelines were categorized as “appropriately ordered”, i.e., tests based on indications shown in the patient’s record. Tests that were ordered which were not required according to the guidelines were categorized as “over-ordered”, i.e., tests not indicated by the patient’s record. Tests that were not ordered but which the guidelines indicated should have been ordered were categorized as “under-ordered”.

The actual number of tests performed in each patient were used to calculate the investigation costs. To illustrate calculate the potential cost savings of following the testing guidelines, total fees for tests actually performed were compared with what the fees would have been if preoperative tests had been ordered done with based on indications as specified in the guidelines. Mathematical analysis was performed using the Statistical Package for Social Sciences, version 20.

## Results

The majority of patients in this study, 333 (97%), underwent major surgery, including intracranial, endoscopic transphenoid, and spine surgery. The other 11 patients (3%) had minor procedures such as ventriculostomy and ventriculo-peritoneal shunt. Most of the patients, 331 or 96%, had a GCS score of 13-15. Of the 344 patients, 196 (57%) were 40-64 years old, with a median of 48.5 years (IQR 36, 57). Ranking tests ordered by age of the patient found that electrocardiography was the only test ordered significantly less frequently in the group 18-39 years (55%), while the test was ordered for 94% of the 40-64 age group and 98% of the ≥ 65 group (Table 2). All patients had CBC and electrolyte preoperative tests and 99% had BUN & Cr performed even though 55% of these patients had CBC test results and 55% had BUN & Cr test results within previous 6 months (Table 3). The least frequently ordered tests, either just prior to surgery or during the previous 6-months, were UA (13% and 3%, respectively) and BS (25% and 13%, respectively). With the exception of UA where 100% of patients required a retest, only a small percentage of patients (0-5%) had reasons to have those tests repeated. Less than 3% of patients who preoperative tests showed abnormal results required further

Code.....operation date ...../...../..... แบบสำรวจและเก็บข้อมูล การส่งตรวจทางห้องปฏิบัติก่อนการผ่าตัดในผู้ป่วยที่มารับการผ่าตัดสมองแบบนัดหมาย

Record form "Preoperative laboratory investigation in elective neurosurgical patients"

Age..... yr Sex☐ M ☐ F Body weight.....kg Height .....cm BMI..... GCS score E.....V.....M..... ASA ☐ I ☐ II ☐ III ☐ IV ☐ V ☐ Chronic smoking ☐ Chronic alcohol ☐ None

Surgical diagnosis..... Operation.....

| Date.... /..... /..... | ☐ CBC | ☐ BUN Cr | ☐ E'lyte | ☐ $CaMgPO_4$ | ☐ PT PTT INR | ☐ Sugar | ☐ LFT | ☐ UA (R/O UTI) | ☐ EKG | ☐ CXR | Normal Range |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Previous lab in 6 mo | ☐ N ☐ Y | ☐ N ☐ Y | ☐ N ☐ Y | ☐ N ☐ Y | ☐ N ☐ Y | ☐ N ☐ Y | ☐ N ☐ Y | ☐ N ☐ Y | ☐ N ☐ Y | ☐ N ☐ Y | Hb men > 13 g/dl<br>Women > 12 g/dl<br>Hct > 33 %<br>Platelet 140,000–400,000<br><br>BUN 6– 20 mg/dl<br>Cr 0.7– .2 mg/dl<br>Na 136 – 14 5 mmol/L<br>K 3.4 – 4.5 mmol/L<br>Cl 98 – 107 mmol/L<br>$HCO_3$ 22 – 29 mmol/L<br>Ca 8.6 – 10.2 mg/dl<br>PO4 2.5 – 4.5 mg/dl<br>Mg 1.32– 2.14 mEq/L<br><br>PT 9.2 – 12.4 sec<br>PTT 25.7 – 37.7 ec<br>INR < 1.5<br><br>Sugar 80 –200 mg/dl<br><br>Alb 3.5 – 5.2 g/dl<br>Glo 3.1 – 3.5 g/dl<br>ALP 40 – 129 U/L<br>AST < 30 U/L<br>ALT < 63 U/L<br>TB < 1.2 U/L<br>DB < 0.3 U/L |
| Result<br>If abnormal, define | ☐ Normal<br>☐..... | ☐ Normal<br>☐..... | ☐ Normal<br>☐..... | ☐ Normal<br>☐..... | ☐ Normal<br>☐..... | ☐ Normal<br>☐..... | ☐ Normal<br>☐..... | ☐ Normal<br>☐..... | ☐ Normal<br>☐..... | ☐ Normal<br>☐..... | |
| Management | ☐ No<br>☐..... | ☐ No<br>☐..... | ☐ No<br>☐..... | ☐ No<br>☐..... | ☐ No<br>☐..... | ☐ No<br>☐..... | ☐ No<br>☐..... | ☐ No<br>☐..... | ☐ No<br>☐..... | ☐ No<br>☐..... | |
| Consider test ordered | O P U | O P U | O P U | O P U | O P U | O P U | O P U | O P U | O P U | O P U | |
| ☐ Age > 45 yrs | ● | ● | | | | | | | ● | ● | |
| ☐ Operation: Major | ● | | | | | | | | | | |
| ☐ HT | | ● | ● | | | ● | | | ● | | |
| ☐ DM | | ● | ● | | | ● | | | | | |
| ☐ CVS: MI,HF,VHD,AF | | | | | | ● | | | ● | ● | |
| ☐ Pulmonary | | | | | | | | | ● | ● | |
| ☐ Malignancy | ● | | | | | | | | | ● | |
| ☐ Hepatoboliary | ● | ● | | | ● | | ● | | | | |
| ☐ Renal | ● | ● | ● | | | | | | | | |
| ☐ Hemato,on anticoag | ● | | | | ● | | | | | | |
| ☐ CNS(stroke,seizure) | ● | | ● | | | ● | | | ● | | |
| ☐ Poor nutrition | ● | ● | ● | | | ● | | | ● | | |
| ☐ On Diuretic | | ● | ● | | | | | | | | |
| ☐ On Digoxin | | ● | ● | | | | | | ● | | |
| ☐ On steroid | ● | ● | ● | | | ● | | | | | |
| ☐ Hypo/ Hyperparathyroid | | | | ● only Ca | | | | | | | |

Peri and post–op event I none I Bleeding > 1000ml I transfusion I AKI I Electrolyte abnormalities I DI I coagulopathy I hypo hyperglycemia I Fever I UTI I pneumonia I arrhythmia I MI I CHF

Remark lab order * IO = over I P = proper I U = under

● As recommended

Adapted from: 1. Table 38–12 Framwork for preoperative diagnostic testing based on patients medical history in Wijeysundera, Duminda N., and Bobbie–Jean Sweitzer. 2015. Miller's Anesthesia Preoperative Evaluation. Eighth Edi. Elsevier Inc. http://dx.doi.org/10.1016/B978–0–7020–5283–5.00038–2 2. แนวทางการส่งตรวจทางห้องปฏิบัติการก่อนผ่าตัด ราชวิทยาลัยวิสัญญีแพทย์ประเทศไทย.

**Figure 1.** Study record form for test ordered in accordance with the guidelines of ASA and RCAT

management. No surgeries were cancelled or delayed due to corrective action resulting from abnormal test results.

The most frequent appropriately ordered, under-ordered, and over-ordered tests were CBC, BS, and PT&PTT, respectively (Figure 2). If those tests had been ordered following the ASA and RCAT guidelines, it would have resulted in a reduction in investigation fees of up to 90% (Figure 3), and would have saved 50% of the amount actually spent on tests.

## Discussion

The authors categorized procedures into two types, "Major" and "Minor", and categorized patients into three age groups to discover whether some tests were selectively performed dependently based on the severity of the procedure or on the age of the patient. None of the 10 preoperative tests were found to have been ordered differently for "Major" and "Minor" neurological procedures. In our institute, neurosurgeons order tests a day or two preoperatively as part of the diagnostic workup, even though some of the tests had previously been done within the previous 6 months. In patients with a stable condition, repeat test results were rarely indicated reasonably for its repeating based on the guidelines (12). Our data showed less than 3% of the tests that had abnormal results required further management. Responses to abnormal tests can vary with different clinicians, specialties, and surgical settings (4).

T**able 1.** Demographic and operation data

| Variable | Total (n=344)* |
|---|---|
| Average age (years) | 48.5 (36, 57)† |
| Age groups: 18-39 / 40-64 / ≥65 | 105 (31%) / 196 (57%) / 42 (12%) |
| Sex: male/ female | 137 (40%) / 207 (60%) |
| ASA: 1/ 2/ 3 | 83 (24%) / 219 (64%) / 42 (12%) |
| Average BMI (kg/m$^2$) | 23.4 (20, 26)† |
| Average GCS score | 15 (15, 15)† |
| GCS score by group: 9-12 / 13-15 | 13 (4%) / 331 (96%) |
| Operation: intracranial / ETSS / spine / shunt procedure | 253 (74%) / 41 (12%) / 39 (11%) / 11 (3%) |
| Operation: major / minor | 333 (97%) / 11 (3%) |

Abbreviations: ASA; American Society of Anesthesiologists, BMI; body mass index, ETSS; endoscopic transphenoid surgery, GCS; Glasgow coma scale, Major; craniotomy, craniectomy, spine surgery, Minor; ventriculostomy, ventriculo-peritoneal shunt, IQR; interquartile range

* Unless stated otherwise, values shown are frequency (percent)

† Median (interquartile range)

**Table 2.** Preoperative tests ordered by age and surgical group

| Test | Age 18-39 years (%) | | Age 40-64 years (%) | | Age >65 years (%) | |
|---|---|---|---|---|---|---|
| | Major (n=98) | Minor (n=8) | Major (n=193) | Minor (n=3) | Major (n=42) | Minor (n=0) |
| 1.CBC | 98 (100%) | 8 (100%) | 193 (100%) | 3 (100%) | 42 (100%) | - |
| 2.UA | 11 (11%) | 3 (38%) | 23 (12%) | 0 | 7 (17%) | - |
| 3.BUN&Cr | 97 (99%) | 8 (100%) | 192 (99%) | 3 (100%) | 42 (100%) | - |
| 4.Electrolytes | 98 (100%) | 8 (100%) | 193 (100%) | 3 (100%) | 42 (100%) | - |
| 5.CaMgPO4 | 85 (87%) | 7 (88%) | 179 (93%) | 3 (100%) | 40 (95%) | - |
| 6.BS | 17 (18%) | 3 (38%) | 47 (24%) | 2 (67%) | 15 (36%) | - |
| 7.PT&PTT | 94 (96%) | 6 (75%) | 184 (95%) | 3 (100%) | 40 (95%) | - |
| 8.LFT | 39 (40%) | 4 (50%) | 96 (50%) | 2 (67%) | 26 (62%) | - |
| 9.ECG | 54 (56%) | 4 (50%) | 181 (94%) | 3 (100%) | 41 (98%) | - |
| 10.CXR | 88 (90%) | 6 (75%) | 184 (95%) | 3 (100%) | 39 (93%) | - |

**Table 3.** Preoperative tests ordered and test results

| Test | Within previous 6 months test order (%) | Current test order (%) | | | Current result (%) | |
|---|---|---|---|---|---|---|
| | | Total | Repeated order | Reason to repeat order* | Abnormal result without further treatment | Abnormal result with further treatment |
| 1.CBC | 189 (55%) | 344 (100%) | 189 (55%) | 9 (5%) | 20 (6%) | 4 (1%) |
| 2.UA | 9 (3%) | 44 (13%) | 6 (2%) | 6 (100%) | 0 | 0 |
| 3.BUN&Cr | 189 (55%) | 342 (99%) | 189 (55%) | 2 (1%) | 5 (2%) | 0 |
| 4.Electrolytes | 190 (55%) | 344 (100%) | 190 (55%) | 2 (1%) | 12 (4%) | 10 (3%) |
| 5.CaMgPO4 | 145 (42%) | 314 (91%) | 145 (42%) | 1 (0.7%) | 2 (0.6%) | 5 (2%) |
| 6.BS | 46 (13%) | 84 (24) | 44 (13%) | 2 (5%) | 1 (0.3%) | 1 (0.3%) |
| 7.PT&PTT | 160 (47%) | 327 (95%) | 159 (46%) | 1 (0.6%) | 8 (2%) | 0 |
| 8.LFT | 75 (22%) | 167 (49%) | 70 (20%) | 0 | 7 (2%) | 0 |
| 9.ECG | 108 (31%) | 283 (82%) | 106 (31%) | 0 | 3 (0.9%) | 1 (0.3%) |
| 10.CXR | 139 (40%) | 320 (93%) | 137 (40%) | 0 | 3 (0.9%) | 0 |

*; With reason to repeat order: percentage calculated from patients who had repeated test order

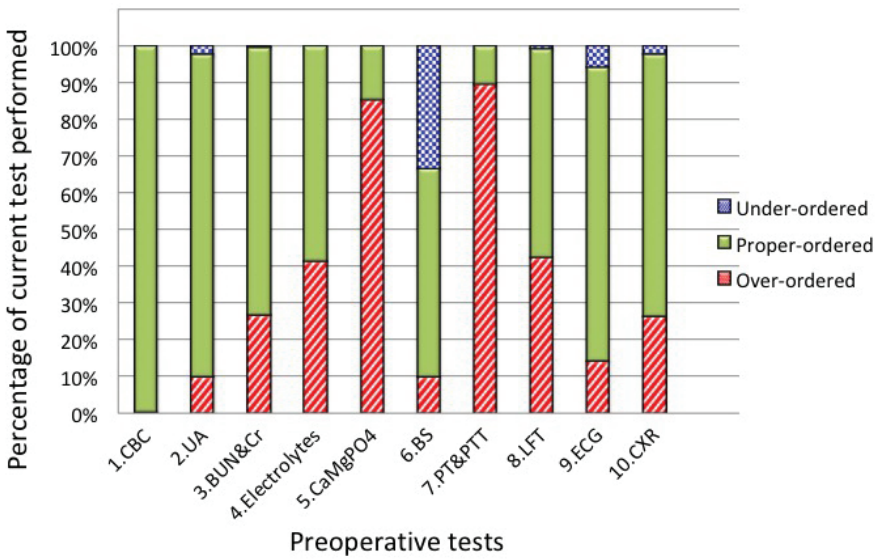


**Figure 2.** Suitability of preoperative tests

Our data do not indicate that the age of the patients was associated with which tests were ordered, with one exception: ECG was ordered less frequently in the youngest age group (<40 years). Even so, that 55% of patients younger than 40 had ECG done. That incidence seemed to be high as ECG was primarily done in patients aged over 50 or 60 to detect asymptomatic coronary artery disease (13-15). In addition, ECG results have little impact on physician management (15-18).

It appeared that some preoperative tests were ordered for patients undergoing elective neurosurgery in our hospital as a matter of routine rather than for specific medical reasons. For example, bleeding is an uncommon, but it is major concern in neurosurgery, so preoperative coagulation tests and platelet counts are routinely performed to detect occult hemostatic disorders (19). Almost all the patients (95%) had PT&PTT done prior to surgery, which is consistent with an Australian neurosurgery study that reported most patients had preoperative PT&PTT screening (19). However, the benefit of routine PT measurement in elective neurosurgical patients with normal

Figure 3.

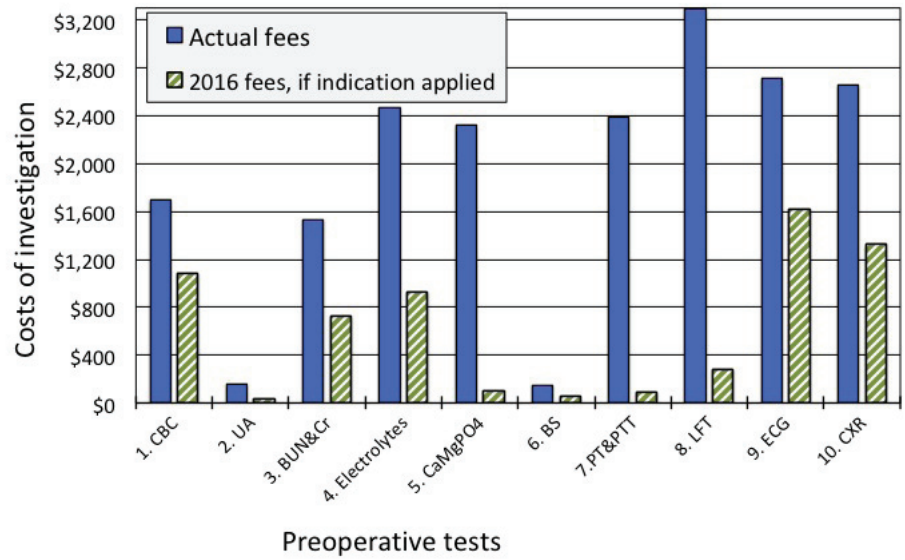


**Figure 3.** Actual fees for tests and potential fees if guidelines were followed

bleeding history has been reported to be trivial (20), while prolonged PTT in patients with a history of bleeding can help predict postoperative bleeding (19).

The authors did not try to determine why some clinicians routinely ordered certain tests before surgery, although other studies have reported that in most instances neurosurgical residents either thought their consultants wanted them to do so or they were simply following the example of senior colleagues (21,22). Another possibility is that the surgeons ordered the tests to protect themselves from potential malpractice lawsuits (23) or that hospital policy dictated obtaining the test results for the anesthesiologists. It has also been reported that anesthesiologists, in order to be respectful, did not cancel any unnecessary tests which had been ordered (24).

A conclusion from systemic reviews (19,25, 26) suggests that there is no benefit from routinely doing preoperative blood screening tests. In fact, with such tests the risks may outweigh the benefits (21,27,28). Previous studies have shown that intervention not medically indicated were related to both significant financial costs and potential harm (29). The authors found 50% of the cost of tests-those ordered which did not follow ASA and RCAT guidelines and repeated tests-could have been saved. Nevertheless we did not survey if there were any adverse consequences either mentally or physically from investigations. Despite the number of previous studies and recommendations regarding the benefits of the guidelines, the adoption of those guidelines in clinical practice has not yet been settled (30,31). In addition, correlation between actual patient outcomes and testing has seldom been demonstrated (32).

Many preoperative tests prior to neurosurgery are over-ordered and unnecessary based on existing guidelines. Ordering tests routinely without a clear purpose can lead to increased costs both in terms of perioperative expenses and time of hospital staff while returning minimal benefit to the patient. Further study of this situation with a larger number of patients should be conducted. Perhaps the findings could then be used to modify standard practice guidelines regarding tests.

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## การประเมินความเหมาะสมสำหรับการส่งตรวจก่อนการผ่าตัดในผู้ป่วยที่มารับการผ่าตัดศัลยกรรมสมองและระบบประสาทแบบนัดหมาย

อานันท์ชนก ศฤงคารินกุล, ปฐมพร ปิ่นอ่อน, ขวัญหทัย คงสินสุขอดุลย์ และ ศิริวรรณ เชื้อสุวรรณ
ภาควิชาวิสัญญีวิทยา คณะแพทยศาสตร์ มหาวิทยาลัยเชียงใหม่

**วัตถุประสงค์** เพื่อศึกษาความเหมาะสมการส่งตรวจก่อนการผ่าตัด 10 ชนิด ในผู้ป่วยที่มารับการผ่าตัดศัลยกรรมสมอง และระบบประสาทแบบนัดหมาย

**วิธีการศึกษา** การศึกษาแบบสังเกตการณ์ไปข้างหน้าในผู้ป่วย จำนวน 344 ราย ที่มารับการผ่าตัดศัลยกรรมสมอง และระบบประสาทแบบนัดหมาย ตั้งแต่เดือนเมษายน พ.ศ. 2559 ถึงเดือนมีนาคม พ.ศ. 2560 การส่งตรวจทางห้องปฏิบัติการและทางรังสี 10 ชนิด ในแง่ของการส่งตรวจปัจจุบันและการส่งตรวจเดิมภายใน 6 เดือนที่ผ่านมา ความผิดปกติที่พบ และผลกระทบต่อการวางแผนด้านวิสัญญีหรือการผ่าตัด ถูกนำมาศึกษา โดยที่ความเหมาะสมของการส่งตรวจนั้นอ้างอิงจากแนวปฏิบัติของสมาคมวิสัญญีแพทย์แห่งสหรัฐอเมริกาและราชวิทยาลัยวิสัญญีแพทย์แห่งประเทศไทย ค่าใช้จ่ายจากการส่งตรวจแต่ละรายการถูกนำมาคำนวณและรวมกัน ข้อมูลถูกแสดงในรูปของความถี่และร้อยละ

**ผลการศึกษา** จากผู้ป่วยทั้งหมด 344 ราย พบว่ามากกว่าร้อยละ 50 มีผลการตรวจเดิมของการตรวจนับเม็ดเลือด (CBC) ค่าการทำงานของไต (BUN&Cr) และอิเล็คโตรไลท์ (electrolytes) ภายใน 6 เดือนที่ผ่านมา แต่ผู้ป่วยเพียงเล็กน้อยที่มีเหตุผลที่จะได้รับการตรวจซ้ำและน้อยกว่าร้อยละ 3 ของผลการตรวจที่ผิดปกติ ต้องการการรักษาเพิ่มเติม การส่งตรวจที่มีความเหมาะสมมากที่สุด คือ การตรวจนับเม็ดเลือด ในขณะที่ระดับน้ำตาลในเลือด (BS) เป็นการส่งตรวจที่ควรทำ แต่ไม่ได้ทำมากที่สุด การส่งตรวจที่ไม่เหมาะสมเกินความจำเป็น 2 อันดับแรก คือ แคลเซียมแมกนีเซียมฟอสเฟต ($CaMgPO_4$) และการแข็งตัวของเลือด (PT&PTT) หากการส่งตรวจทั้งหมดได้ทำตามแนวปฏิบัติที่เป็นมาตรฐาน ของสมาคมวิสัญญีแพทย์แห่งสหรัฐอเมริกาและราชวิทยาลัยวิสัญญีแพทย์แห่งประเทศไทย จะช่วยลดค่าใช้จ่ายจากการส่งตรวจได้มากถึงร้อยละ 90 จากค่าการตรวจการทำงานของตับ (LFT) แคลเซียมแมกนีเซียมฟอสเฟต ($CaMgPO_4$) และการแข็งตัวของเลือด (PT&PTT)

**สรุปผลการศึกษา** การส่งตรวจก่อนการผ่าตัดที่เกินความจำเป็นพบได้บ่อยในโรงพยาบาลมหาราชนครเชียงใหม่ ผลการศึกษาอาจช่วยชี้นำศัลยแพทย์ในการสั่งตรวจก่อนการผ่าตัดเฉพาะที่เหมาะสมและจำเป็น **เชียงใหม่เวชสาร 2561;57(3):127-34.**

**คำสำคัญ:** การส่งตรวจ ก่อนการผ่าตัด การผ่าตัดศัลยกรรมสมองและระบบประสาท เป็นกิจวัตร