Factors Associated with Hemofilter Clotting in Patients with Acute Kidney Injury Requiring Continuous Renal Replacement Therapy

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Abstract

Background: Hemofilter clotting compromises efficacy of continuous renal replacement therapy (CRRT). However, risk factors associated with filter clotting are not well characterized. Recently, a new calculation of filtration fraction (FF) which incorporates systemic and post-filter hematocrit into the formula (FF_{Hct}) has been purposed. This study aimed to evaluate the associations between FF_{Hct}, conventional FF, and other related factors with filter survival in patients receiving CRRT.

Method: This prospective cohort study was conducted in patients with acute kidney injury undergoing CRRT without anticoagulation. Factors related to filter clotting were documented at baseline and every 8 hours for 72 hours or until filter loss.

Results: Twenty-one patients using 48 filters were included. The median filter survival was 20.5 hours, and all filters clotted within 72 hours. In the multivariate analysis, the independent predictors for filter clotting were FF_{Hct} ≥ 20% (HR: 2.18, 95% CI: 1.10 - 4.31, p=0.03), sites of dialysis catheter other than the right internal jugular vein (HR: 2.23, 95% CI: 1.16 - 4.29, p=0.02), and platelet count ≥100,000 /µl (HR: 2.22, 95% CI: 1.08 - 4.60, p=0.03). Arterial pressure circuit (<-150 mmHg), sieving coefficient (<0.9), conventional FF cut-off of (≥20%), and post-filter hematocrit (≥35%) were not associated with filter survival.

Conclusion: FF_{Hct} ≥ 20% was an independent predictor of decreased filter lifespan in patients with acute kidney injury undergoing CRRT without anticoagulation. Future trials are needed to validate these preliminary findings.

Key Words: hemodialysis; renal replacement therapy; RRT; dialyzer; dialysis; acute renal failure

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ปัจจัยที่มีความสัมพันธ์กับการอุดตันของตัวกรองในผู้ป่วยไตวายเฉียบพลันที่ได้รับการบำบัดทดแทนไตแบบต่อเนื่อง

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บทคัดย่อ

บทนำ: การอุดตันของตัวกรองเป็นปัจจัยสำคัญ ที่ทำให้ประสิทธิภาพของการบำบัดทดแทนไตแบบต่อเนื่องลดลง ข้อมูลที่เกี่ยวข้องกับปัจจัยเสี่ยงต่อการอุดตันของตัวกรอง ในการบำบัดทดแทนไตอย่างต่อเนื่องยังมีอยู่น้อย เร็วๆ นี้ได้มีการกล่าวถึงการคำนวณ filtration fraction (FF) วิธีใหม่ โดยนำค่าความเข้มข้นเลือดก่อนผ่านตัวกรอง และหลังผ่านตัวกรอง (FF_{Hct}) มาใช้ในสูตร ซึ่งอาจเป็นวิธีที่ดีกว่าในการประเมินความเสี่ยงต่อการอุดตันของตัวกรอง การศึกษานี้มีวัตถุประสงค์เพื่อประเมินความสัมพันธ์ระหว่าง ค่า FF_{Hct}, ค่า FF ที่คำนวณด้วยวิธีเก่า (conventional FF) รวมถึงปัจจัยอื่นๆที่เกี่ยวข้อง กับการอุดตันของตัวกรองในผู้ป่วยที่ได้รับการรักษาด้วยการบำบัดทดแทนไตแบบต่อเนื่อง

ระเบียบวิธีวิจัย: การศึกษานี้เป็นการศึกษาแบบไปข้างหน้า ในผู้ป่วยไตวายเฉียบพลันที่ได้รับการบำบัดทดแทนไตแบบต่อเนื่องที่ไม่ได้รับสารป้องกันการเกิดลิ่มเลือด การเก็บข้อมูลปัจจัยเสี่ยงที่มีความสัมพันธ์กับการอุดตันของตัวกรอง จะเริ่มตั้งแต่ก่อนการบำบัดทดแทนไตและเก็บข้อมูลทุก 8 ชั่วโมง เป็นเวลา 72 ชั่วโมง หรือจนกว่าตัวกรองจะใช้งานไม่ได้

ผลการศึกษา: ผู้ป่วยเข้าร่วมการศึกษาทั้งหมด 21 คน โดยใช้ตัวกรองทั้งหมด 48 ตัว พบว่าอายุการใช้งานของตัวกรอง มีค่ามัธยฐาน 20.5 ชั่วโมง ตัวกรองทั้งหมดเกิดการอุดตันก่อน 72 ชั่วโมง จากการวิเคราะห์แบบพหุตัวแปรพบว่า ปัจจัยที่มีความสัมพันธ์กับอายุที่สั้นลงของตัวกรอง คือ FF_{Hct} ≥ร้อยละ 20 (HR: 2.18, 95% CI: 1.10 - 4.31, p=0.03) การมีสายฟอกเลือดตำแหน่งอื่นที่ไม่ใช่ internal jugular vein ด้านขวา (HR: 2.23, 95% CI: 1.16 - 4.29, p=0.02) และปริมาณเกล็ดเลือด ≥100,000 ต่อไมโครลิตร (HR: 2.22, 95% CI: 1.08 - 4.60, p=0.03) ส่วนค่าความดัน arterial ในวงจรการบำบัดทดแทนไต (<-150 มม.ปรอท) ค่า sieving coefficient (<0.9) ค่า conventional FF (≥ร้อยละ 20) และ ค่าความเข้มข้นของเลือดหลังตัวกรอง (≥ร้อยละ 35) ไม่มีความสัมพันธ์กับอายุของตัวกรอง

สรุป: ในผู้ป่วยไตวายเฉียบพลันที่ได้รับการบำบัดทดแทนไตแบบต่อเนื่อง โดยไม่ใช้สารป้องกันการเกิดลิ่มเลือด ค่า FF_{Hct} ≥ร้อยละ 20 มีความสัมพันธ์กับอายุการใช้งานของตัวกรองที่สั้นลง อย่างไรก็ตามจำเป็นที่จะต้องรอผลการศึกษาจากงานวิจัยในอนาคตเพื่อยืนยันผลการศึกษาเบื้องต้นนี้

คำสำคัญ: ฟอกเลือด; การฟอกเลือดด้วยเครื่องไตเทียม; เฮพาริน; ไตวาย; ฟอกไต; ไตบาดเจ็บ

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Introduction

Continuous renal replacement therapy (CRRT) is a preferred modality of renal replacement therapy in critically ill patients with acute kidney injury (AKI) and hemodynamic instability. Adequacy of CRRT depends on several factors including well-functioning vascular access, the modality and dose of CRRT and the use of anticoagulation to ensure patency of the filter and circuit[1]. The 2012 Kidney Disease Improving Global Outcomes (KDIGO) Clinical Practice Guideline for Acute Kidney Injury recommends regional citrate anticoagulation to prolong filter lifespan in those without contraindications, i.e., impaired liver function, shock with muscle hypoperfusion or high serum lactate[2]. However, patients in the intensive care unit often present with metabolic acidosis, high serum lactate and coagulopathy[3,4]. Moreover, the safety of regional citrate anticoagulation requires monitoring of ionized calcium, and the test is available only in large tertiary care hospitals. These limitations prohibit the use of regional citrate anticoagulation as well as systemic heparinization during CRRT. Threfore, CRRT is commonly performed without anticoagulant, which increases the risk of filter clot resulting in decreased treatment efficacy and increased risk of blood loss.

The risk of filter clotting also depends on other factors such as stasis of blood flow and hyperviscosity within the filter. This could be assessed by post-filter hematocrit or calculation of filtration fraction (FF), which is the ratio of ultrafiltrate flow rate to plasma flow rate. The recommended FF cut-off to prevent filter clotting is typically below 25% in post-dilution CRRT[5]. The data on the optimum cut-off value of FF was derived from the studies in 1980s that used continuos arteriovenous hemofiltration (CAVH) as the primary mode of CRRT[6,7]. In CAVH, the ultrafiltration rate cannot be precisedly controlled limiting the applicability of the results to continuous venovenous hemofiltration (CVVH), which is the most comonly used mode of CRRT at present. Moreover, the reported FF in the previous study was merely the observed value in terms of the achievement of solute clearance, not filter clotting. The later study in 1992 demonstrated that post-filter hematocrit closed to 45% was a predictor of filter clotting. Again, the primary mode of CRRT in the study was also CAVH[8].

The end-of-filter hematocrit reflects the degree of hemoconcentration which may be more relevant than the conventional FF in predicting the risk of filter clotting. Recently, a new equation of FF deriving from pre-filter and post-filter hematocrits (FF_{Hct}) has been proposed [6,15]. However, the optimum FF_{Hct} value for preventing filter clotting is unknown. The objective of this study is to evaluate the associations between FF_{Hct}, conventional FF, post-filter hematocrit, and other related factors with filter survival in patients receiving CRRT.

Materials and methods

Study design and participants

This was a single center prospective cohort study conducted in the medical intensive care unit at Siriraj Hospital, Mahidol University, Bangkok, Thailand during July 2021 to July 2022. The study was approved by the Ethics Committee of Siriraj Hospital, Mahidol University. Informed consent was obtained from all participants. Patients who were at least 18 years old, diagnosed with AKI, and fulfilled the indication for CRRT without anticoagulation were included. The exclusion criteria were patients with chronic kidney disease stage 5 or end-stage kidney disease and those receiving systemic anticoagulation.

Data collection

Demographic data were recorded at baseline. Laboratory tests were collected at baseline and then every 8 hours for 72 hours or until filter loss. Filter lifespan was defined as the time from initiation of CRRT until filter loss. For calculations of FFs and sieving coefficient, the effluent urea nitrogen concentration, BUN, pre-filter hematocrit, and post-filter hematocrit were collected. Sieving coefficient was a ratio of urea nitrogen concentration in the effluent to BUN. Conventional FF and FF_{Hct} were calculated as follows[15]:

$$\text{Conventional FF for CVVH} = \frac{Q_{eff}}{QB \times (1\text{-}Hct_{pre}) + Q_{RF\text{-}pre}}$$

$$\text{Conventional FF for CVVHD} = \frac{Q_{Net\text{-}UF} + Q_{RF\text{-}pre} + Q_{RF\text{-}post}}{QB \times (1\text{-}Hct_{pre}) + Q_{RF\text{-}pre}}$$

$$FF_{Hct} = \frac{Hct_{post} - Hct_{pre}}{Hct_{post} \times (1\text{-}Hct_{pre})}$$

Qeff, effluent flow rate = $Q_{Net\text{-}UF}+Q_{RF\text{-}pre}+Q_{RF\text{-}post}$; QB, blood flow rate; Hct, hematocrit; Hct_{pre}, pre-filter Hct; Hct_{post}, post-filter Hct; $Q_{Net\text{-}UF}$, net ultrafiltration rate; $Q_{RF\text{-}pre}$, pre-dilution replacement fluid rate; $Q_{RF\text{-}post}$, post-dilution replacement fluid rate

Continuous renal replacement therapy prescription

The size of double lumen dialysis catheters was 11-11.5 French. The lengths of double lumen dialysis catheter for right internal jugular vein, left internal jugular vein and femoral vein cannulation were 12, 15 and 24 centimeters, respectively. CRRT was performed using a Prismaflex M100 hemofilter with initial prescribed effluence dose of 30 ml/kg/hour, which can be adjusted according to the patient's status by the attending nephrologist. If the prescribed dose was ≤2000 ml/hr, CVVH mode was performed with a ratio of $Q_{RF\text{-}pre}$: $Q_{RF\text{-}post}$ = 1:1. If the prescribed dose was >2000 ml/hr, CVVHDF was performed using fixed rates of $Q_{RF\text{-}pre}$ at 1000 ml/hr and $Q_{RF\text{-}post}$ at 500 ml/hr with dialysate flow rate adjusted to achieve the total effluence dose. The replacement fluid was bicarbonate-buffered solution. The parameters associated with CRRT treatment including blood flow rate, arterial pressure, venous pressure, transmembrane pressure, effluent flow rate and net fluid loss were recorded hourly.

Outcomes

The primary outcome was hemofilter survival. The secondary outcomes were the associations between FF_{Hct}, conventional FF, post-filter hematocrit and other related parameters with hemofilter survival.

Sample size calculation

The sample size was calculated by using the incidence of filter clotting reported by MacEwen et al[9]. Aiming for 80% power to detect an effect at an alpha level of 0.05 for predicting 78.2% of filter clotting would require a total of 77 filters.

Statistical analysis

Data were presented as mean ± standard deviation, median (interquartile range) or frequency (percentage). Filter lifespan was evaluated using Kaplan-Meier method. Cox's Proportional Hazard model was used to evaluate factors associated with filter survival. Factors with p-value ≤0.1 from the univariate analysis and other relevant factors were selected as covariates in the multivariate model. Cox's Proportional Hazard model was performed with backward stepwise likelihood ratio method. The statistical analyses were performed using SPSS software (IBM spss. 25.0, SPSS Inc). P-value <0.05 was considered statistically significant.

Results

A total of 21 patients and 48 filters were included in this study. Baseline demographic and laboratory data of all patients are presented in **Table 1**. The mean age was 62.9±13.1 years, 52% were female. The average SOFA and APACHE II scores at the time of initiation of CRRT were 13.7±3.4 and 30.7±6.1, respectively. The average serum creatinine was 3.1 mg/dL. The two main indications for dialysis initiation were metabolic acidosis (61.9%) and volume overload (52.4%). The average hematocrit was 27±6%. Sixty seven percent had at least one bleeding risk (platelet count <40,000/µl, INR >1.5, aPTT >60 seconds, receiving antiplatelets or anticoagulants, or prior bleeding within 7 days). All antiplatelets and anticoagulants were withheld prior to initiation of CRRT in all participants, this was due to the attending physician's decision.

Table 1. Baseline demographics and laboratory data of all patients

Parameters	N=21
Age, years	62.9±13.1
Female, n (%)	11 (52.4)
Body weight, kg	71.6±24.4
Body mass index, kg/m^2	27.2±8.4
Mechanical ventilation, n (%)	21 (100)
Mean arterial pressure, mmHg	86.2±15.2
Central venous pressure, mmHg	17.1±5.3
Norepinephrine, µg/kg/min	0.11 (0.07, 0.26)
Adrenaline, µg/kg/min	0.22±0.99
SOFA score	13.7±3.4
APACHE II score	30.7±6.1
Comorbidities, n (%)	
Diabetes mellitus	10 (47.6)
Hypertension	12 (57.1)
Dyslipidemia	8 (38.1)
Coronary artery disease	2 (9.5)
Cerebrovascular disease	1 (4.8)
Chronic kidney disease	6 (28.6)
Others	8 (38.1)
Indications for CRRT, n (%)	
Metabolic acidosis	13 (61.9)
Volume overload	11 (52.4)
Hyperkalemia	3 (14.3)
Uremia	1 (4.8)
Laboratory investigations	
Hematocrit, %	27±6
Platelets x 10^3/µl	99 (69, 211.5)
PT, seconds	17.5 (14.4, 30.8)
INR	2.5 (1.4, 3.4)
aPTT, seconds	42.8±18.0
BUN, mg/dl	56.3±27.7
Creatinine, mg/dl	3.1 (2.0, 5.3)
Potassium, mmol/l	4.4±0.8
HCO_3, mmol/l	14.1±5.2
Lactate, mmol/l	4.4 (2.2, 13.0)

SOFA, Sequential Organ Failure Assessment; APACHE, Acute Physiology And Chronic Health Evaluation; CRRT, continuous renal replacement therapy; PT, prothrombin time; INR, international normalized ratio; aPTT, activated partial thromboplastin time; HCO_3, bicarbonate

Dialysis catheter placement sites were right femoral vein in 11 patients (52.4%), right internal jugular vein in 8 patients (38.1%), left internal jugular vein in 1 patient (4.8%), and left common femoral vein in 1 patient (4.8%). Sixty percent of the patients received CVVH and 40% received CVVHDF. The average initial CRRT dose was 30±8 ml/kg/hour. Baseline parameters of CRRT and parameters nearest to the time of filter clot are shown in **Table 2**. The average blood flow rate was 170±36 ml/min. At the beginning of CRRT, conventional FF was 19.7±7.9%, and FF_{Hct} was 19.5±13.8%. All filters clotted within 72 hours. The median filter lifespan was 20 hours and 30 minutes (interquartile range 688 to 2,293 minutes). The duration between the collection of parameters at the time nearest to filter clotting and the actual filter clotting time ranged between 30 minutes to 8 hours. The average conventional FF and FF_{Hct} were 18.2±3.6% and 19.0±9.0%, respectively. The average post-filter hematocrit was 31±5% and the average sieving coefficient was 0.92±0.08.

In univariate analysis, dialysis catheter placement sites other than the right internal jugular vein, systemic hematocrit ≥28%, platelet count ≥100,000/µl, arterial pressure <-150 mmHg, venous pressure ≥115 mmHg and transmembrane pressure ≥260 mmHg were significantly associated with decreased filter lifespan (**Table 3**). There was no association between post-filter hematocrit of ≥35% with filter survival. For post-filter hematocrit of ≥40%, the number of patients was too small for a meaningful assessment. In multivariate analysis, factors that were independently associated with decreased filter lifespan were FF_{Hct} ≥20%, dialysis catheter placement site other than the right internal jugular vein, and platelet count ≥100,000/µl. Kaplan-Meier survival curve according to FF_{Hct} <20% and ≥20% at the time of clotting is illustrated in **Figure 1**.

Table 2 Baseline parameters of continuous renal replacement therapy and parameters at the time nearest to filter clot

Parameters (N = 48)	Baseline	At the time nearest to filter clotting
Conventional FF, %	19.7±7.9	18.2±3.6
FF_{Hct}, %	19.5±13.8	19.0±9.0
Sieving coefficient of urea	0.94±0.06	0.92±0.08
Post-filter hematocrit, %	31±9	31±5
Pre-filter hematocrit, %	26±4	27±4
Systemic hematocrit, %	27±5	28±3
Arterial pressure, mmHg	-84±43.5	-147±37
Venous pressure, mmHg	78±40	116±53
Transmembrane pressure, mmHg	89±2	268±90
Blood flow rate, ml/min	170±36	199±7
Pre-dilution replacement flow rate, ml/hr	928±142	975±149
Post-dilution replacement flow rate, ml/hr	738±231	808±243
Dialysate flow rate, ml/hr	922±418	1179±593
Total effluent outflow, ml/hour	2,062±520	2,274±635
Fluid loss, ml/kg/hour	0 (0, 0.5)	0.8 (0.0, 1.6)
Platelet x 10^3, /ul	98 (54, 170)	91 (51, 162)
PT, seconds	18 (15, 40)	18 (15, 30)
INR	1.9 (1.5, 2.8)	1.8 (1.4, 2.5)
aPTT, seconds	40±13	37±7

FF, filtration fraction; PT, prothrombin time; INR, international normalized ratio; aPTT, activated partial thromboplastin time; CRRT, continuous renal replacement therapy; FF, filtration fraction

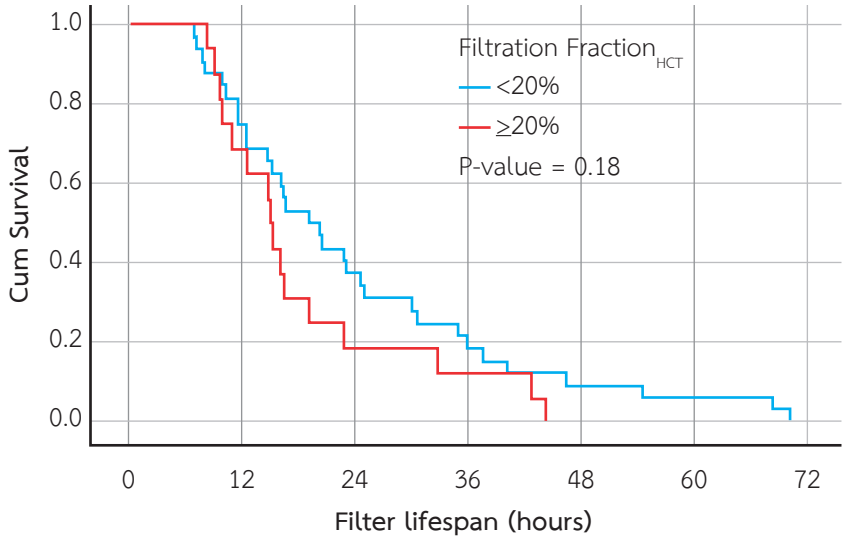

Figure 1. Filter survival according to the filtration fraction$_{Hct}$ <20% and ≥20%
Hct, hematocrit

Table 3 Univariate and multivariate analyses of factors associated with filter clotting

Factors		N	Univariate		Multivariate	
			HR (95%CI)	P-value	HR (95%CI)	P-value
Conventional FF	< 20% ≥ 20%	34 14	1.00 (reference) 1.12 (0.59, 2.11)	0.73	1.00 (reference) 1.40 (0.68, 2.88)	0.37
FF_{Hct}	< 20% ≥ 20%	32 16	1.00 (reference) 1.54 (0.83, 2.85)	0.18	1.00 (reference) 2.18 (1.10, 4.31)	0.03
FF_{Hct}	< 25% ≥ 25%	43 5	1.00 (reference) 2.02 (0.77, 5.30)	0.15	-	-
Post-filter Hct	< 35% ≥ 35%	41 7	1.00 (reference) 0.73 (0.31, 1.74)	0.48	-	-
Post-filter Hct	< 40% ≥ 40%	46 2	1.00 (reference) 2.38 (0.55, 10.34)	0.48	1.00 (reference) 1.92 (0.31, 11.68)	0.48
Pre-filter Hct	< 28% ≥ 28%	30 18	1.00 (reference) 0.91 (0.50, 1.65)	0.74	-	-
Systemic Hct	< 28% ≥ 28%	24 24	1.00 (reference) 1.83 (1.02, 3.28)	0.04	1.00 (reference) 1.44 (0.69, 3.00)	0.33
Sieving coefficient	≥ 0.9 < 0.9	34 14	1.00 (reference) 0.79 (0.41, 1.50)	0.47	1.00 (reference) 1.46 (0.66, 3.23)	0.35
Vascular access site	Rt IJV Non-Rt IJV	20 28	1.00 (reference) 2.37 (1.26, 4.48)	<0.01	1.00 (reference) 2.23 (1.16, 4.29)	0.02
Inotropic drug	No Yes	11 37	1.00 (reference) 1.12 (0.56, 2.21)	0.75	-	-
Mode of CRRT	CVVHDF CVVH	19 29	1.00 (reference) 1.00 (0.55, 1.82)	0.99	-	-
Dose of CRRT (ml/kg/hr)	< 30 ≥ 30	17 31	1.00 (reference) 1.70 (0.89, 3.24)	0.11	-	-
Arterial pressure (mmHg)	≥ -150 < -150	27 21	1.00 (reference) 2.20 (1.15, 4.22)	0.02	1.00 (reference) 1.81 (0.92, 3.57)	0.09
Venous pressure (mmHg)	< 115 ≥ 115	25 23	1.00 (reference) 2.02 (1.06, 3.85)	0.03	1.00 (reference) 1.01 (0.38, 2.65)	0.99
TMP (mmHg)	< 260 ≥ 260	21 27	1.00 (reference) 1.97 (1.08, 3.58)	0.03	1.00 (reference) 1.54 (0.82, 2.91)	0.18
Platelet count x 10^3 (cells/μL)	< 100,000 ≥ 100,000	26 22	1.00 (reference) 2.43 (1.27, 4.64)	<0.01	1.00 (reference) 2.22 (1.08, 4.60)	0.03
PT (seconds)	≥ 20 < 20	23 25	1.00 (reference) 1.24 (0.70, 2.20)	0.47	-	-
INR	≥ 1.5 < 1.5	39 9	1.00 (reference) 1.99 (0.83, 4.74)	0.12	-	-
aPTT (seconds)	≥ 35 < 35	29 19	1.00 (reference) 1.20 (0.67, 2.16)	0.54	-	-

HR, hazard ratio; CI, confidence interval; FF, filtration fraction; TMP, transmembrane pressure; Hct, hematocrit; IJV, internal jugular vein; CRRT, continuous renal replacement therapy; CVVH, continuous venovenous hemofiltration; CVVHDF, continuous venovenous hemodiafiltration; PT, prothrombin time; INR, international normalized ratio; aPTT, activated partial thromboplastin time

Discussion

The main findings of the present study included several factors that were identified as independent risk factors for decreased filter survival in patients undergoing CRRT without anticoagulant. These risk factors included FF_{Hct} of ≥20%, dialysis catheter placement site other than the right internal jugular vein, and platelet count of ≥100,000/µl. However, there were no associations between conventional FF ≥20%, post-filter hematocrit ≥35%, sieving coefficient <0.9, and arterial pressure <-150 with filter lifespan.

The association between FF_{Hct} ≥20% and decreased filter lifespan may be attributed to a more accurate representation of the end-of-filter hemoconcentration. Unlike conventional FF formula, which incorporates ultrafiltration, blood flow, pre-dilution and post-dilution replacement fluid rates, FF_{Hct} utilizes only pre-filter and post-filter hematocrit values. In the situation where post-filter replacement fluid is prescribed, the post-filter hematocrit rises exponentially as the rate of replacement fluid increases. On the other hand, the rate of pre-filter replacement fluid has minimal impact on the post-filter hematocrit. Since hemoconcentration, rather than filtration fraction itself, defines the risk of clot formation, the conventional FF formula may not accurately reflect the extent of end-of-filter hemoconcentration. Therefore, FF_{HCt} may serve as a better alternative to the conventional FF in assessing the risk of filter clotting.

Although post-filter hematocrit has been commonly used as an indicator of hemoconcentration, the present study did not establish an association between post-filter hematocrit of 35% or higher and decreased filter lifespan. Additionally, the number of filters with post-filter hematocrit of 40% or higher was too small for meaningful analysis. The average sieving coefficient at the time of filter clotting was 0.92 indicating sufficient solute clearance, suggesting that other factors were responsible for filter clotting. The association between dialysis catheter placement site other than the right internal jugular vein and decreased filter survival may be explained by the direct route of the right internal jugular venous catheter into the right atrium providing better blood flow with less turbulence. This finding aligns with the recommendation from the KDIGO guideline, which suggests the use of right internal jugular vein as the first choice for dialysis catheter placement[3].

The median filter lifespan in the present study was 20.5 hours which was comparable with the data from the prior systematic review and meta-analysis that reported the average filter lifespan of 22±11 hours[8]. Several randomized controlled trials have demonstrated the benefit of CVVHDF in prolonging filter survival (44% lower failure rate) when compared with CVVH[10–12]. However, the present study did not find a significant difference between the mode of CRRT on filter survival. As for other CRRT parameters, there were no associations between arterial pressure and transmembrane pressure of the CRRT circuit with filter survival. On the other hand, the previous study reported the association between increased transmembrane pressure with the risk of filter clotting[13]. The present study revealed the association between increased platelet count with decreased filter survival. Similar finding was reported by the previous single-center, retrospective, observational study conducted at a tertiary referral center in Melbourne, Australia[14]. This same study also reported an increase in filter lifespan with higher blood flow rate. However, the present study used a fixed blood flow rate preventing an analysis of different blood flow rates on filter clotting.

The present study was limited by the collection of data every 8 hours instead of continuous monitoring resulting in a lag time between the last dataset and the time of filter clotting. The variation in blood flow rates as a result of vascular access problems was neither recorded nor considered in the calculation. The statistical power is also likely to be affected by the small sample.

Conclusion

FF_{Hct} was an independent predictor of decreased hemofilter survival in patients with AKI who underwent CRRT without anticoagulation. This finding suggests that FF_{Hct} could serve as a compelling alternative to the conventional FF in assessing the risk of filter clotting. Furthermore, increased platelet count and dialysis

catheter placement sites other than the right internal jugular vein were also identified as predictors of decreased filter lifespan. However, it is important to note that these findings should be further validated through future studies with larger sample size to solidify their significance and clinical implications.

Authors' contribution

Salinthip Tiaochoktrakul, Kornchanok Vareesangthip, Thummaporn Naorungroj and Thawee Chanchairujira contributed to the Initiation (idea), conceptualization of hypothesis, the research operation, data curation, storage, data analysis and interpretation, criticism of the results, writing and reviewing the manuscript.

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