Quality matters: Filter Life in CRRT

San Diego, 21st AKI & CRRT Conference, Feb 16th – 19th 2016

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Dept. of Intensive Care

Austin Health, Melbourne Australia
Deakin & RMIT University
Circuit clotting (failure): sources

- Anticoagulation technique and failures
- The patients?
- The circuit and components of this?
- Machine & users errors?
- What is ‘normal’ filter ‘life’ & findings of others?
Clotting and ‘plugging’
Some clotting in ~85% of all circuits

Top: at blood level

Bottom: at chamber filter

Clot formation in venous air trap chamber
Issues with the critically ill….

Variability in daily coag. results

AT-3 deficiency
Plts falling – replacement
Sepsis, cytokine release
Surgical, neuro, cardiac
Liver failure
Liver failure:

• 44 female, with ALF following hemi heptatectomy for Fibronodular tumour and portal vein thrombosis 3 weeks ago. (110 kg = 242 lbs)
Past history: IVF, married, 1 child, works in sales.
Present: increasing jaundice, abdo pain, drowsiness, Oliguria.....
Filter Life (hr) ~ 2 weeks, no anticoagulation

Median 6.0 hrs
Average 7.5 hrs

Access GW exchanged
Frequent clotting – poor circuit life

Circuit lifespan during continuous renal replacement therapy for combined liver and kidney failure

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d Division of Nephrology, University Medicine Cluster, National University Hospital, National University Health System, Singapore
## Findings

All circuits median = 9.0 hrs

### Table 2: CRRT circuit profile

<table>
<thead>
<tr>
<th>Circuit characteristics</th>
<th>ALL circuits</th>
<th>Circuits of patients with no AC throughout</th>
<th>Circuits of patients with no AC initially, but with subsequent AC</th>
<th>P&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 539</td>
<td>n = 230</td>
<td>Initial AC free</td>
<td>Systemic heparin</td>
</tr>
<tr>
<td>Circuit lifespan, median (IQR), h</td>
<td>9.0 (6.0-15.5)</td>
<td>12.0 (7.0-24.0)</td>
<td>7.0 (5.0-10.5)</td>
<td>7.5 (5.0-13.5)</td>
</tr>
<tr>
<td>CVVH/CVVHDF, No.</td>
<td>330/209</td>
<td>160/70</td>
<td>112/76</td>
<td>10/19</td>
</tr>
<tr>
<td>Vascular access, No. (%)</td>
<td>503 (93.3)</td>
<td>196 (85.2)</td>
<td>186 (98.9)</td>
<td>29 (100.0)</td>
</tr>
<tr>
<td>Femoral vein</td>
<td>36 (6.7)</td>
<td>34 (14.8)</td>
<td>2 (1.1)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Internal jugular/subclavian vein</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prescribed intensity, median (IQR), mL/kg per h</td>
<td>32.8 (22.2-50.0)</td>
<td>30.8 (24.1-40.0)</td>
<td>40.0 (22.2-50.0)</td>
<td>28.6 (22.2-50.0)</td>
</tr>
<tr>
<td>Heparin dose, median (IQR), U/kg per h</td>
<td>NA</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>6.4 (5.8-8.3)</td>
</tr>
<tr>
<td>Circuit hematology profile&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hemoglobin, median (IQR), g/dL</td>
<td>8.1 (7.4-9.3)</td>
<td>8.1 (7.3-9.1)</td>
<td>8.3 (7.6-9.4)</td>
<td>7.6 (7.4-8.6)</td>
</tr>
<tr>
<td>Platelet count, median (IQR)</td>
<td>49 (32-84)</td>
<td>51 (34-97)</td>
<td>45 (29-67)</td>
<td>58 (45-76)</td>
</tr>
<tr>
<td>INR, median (IQR)</td>
<td>2.3 (1.8-3.0)</td>
<td>2.3 (1.9-3.0)</td>
<td>2.2 (1.7-2.9)</td>
<td>2.5 (1.6-2.9)</td>
</tr>
<tr>
<td>APTT, median (IQR), seconds</td>
<td>46 (38-57)</td>
<td>48 (40-61)</td>
<td>43 (37-52)</td>
<td>64 (40-87)</td>
</tr>
</tbody>
</table>

<sup>a</sup> Circuits of patients who were never anticoagulated throughout for CRRT (51 patients).

<sup>b</sup> Circuits of patients who were not anticoagulated initially, but subsequently received heparin for CRRT (20 patients).

<sup>c</sup> Hematology results obtained before each circuit or during initial hours from each circuit commencement.

<sup>d</sup> Comparing only results of last 3 columns.
My ICU; Median Filter ‘life’ data 1996-2003

Mean = 20.08 hrs (NB: 2 RCT’s in year 2009, 2010 21 hrs)
## Large Multicentre, RCT – RRT Dose

<table>
<thead>
<tr>
<th>Study (circuits) RCT’s</th>
<th>Anticoag</th>
<th>Definition</th>
<th>Mean (hrs)</th>
<th>Median (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RENAL 2009, Aus</td>
<td>Heparin or nil</td>
<td>Nil</td>
<td>28.5*</td>
<td>25.8*</td>
</tr>
<tr>
<td>722 + 743 pts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3701 (low group)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4253 (high group)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARF TN (ATN) 2008</td>
<td>Heparin or nil</td>
<td>Nil</td>
<td>20.9</td>
<td>21.0</td>
</tr>
<tr>
<td>USA 563 + 561 pts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3178 (Intensive)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2789 (less intensive)</td>
<td>Citrate</td>
<td>Avg.</td>
<td>27.1 24.0 hr</td>
<td>20.9</td>
</tr>
<tr>
<td>~13921 circuits</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Calculated based on 0.93 and 0.84 per day
# Audits, single centre anticoag. trials

<table>
<thead>
<tr>
<th>Study (patients/circuits)</th>
<th>Anticoag</th>
<th>Definition</th>
<th>Mean (hrs)</th>
<th>Median (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uchino S 2004 48/300</td>
<td>Heparin or nil Protamine</td>
<td>Nil</td>
<td>20.9 19.3 21.2</td>
<td></td>
</tr>
<tr>
<td>Monchi M 2004 20/49(23+26) Brophy P 2005 multicentre(peds) 138/442</td>
<td>Heparin Citrate Heparin Citrate</td>
<td>TMP &gt; 300 Nil</td>
<td>42.1 44.7 40.0 70.0</td>
<td></td>
</tr>
<tr>
<td>Kutsogiannis D 2005 31/79(43+36) Joannidis M 2007 37/77(38 + 39) Oudemans van Straaten 2009 200/ n.a.</td>
<td>Heparin Citrate Heparin Enoxaparin Citrate Nadroparin</td>
<td>Cont. TMP &gt; 200 TMP &gt; 350 or spont. Pin or TMP &gt; 300 Avg.</td>
<td>38.3 124.5 21.7 30.6 27.0 26.0 29.6 38.4 hr 47.3</td>
<td></td>
</tr>
</tbody>
</table>
## Citrate studies published

<table>
<thead>
<tr>
<th></th>
<th>CVVH</th>
<th>CVVHDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. studies</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>Median filter life</td>
<td>31.5</td>
<td>57.6</td>
</tr>
</tbody>
</table>

- 29.5
- 45.4
- 29.5
- 70
- 17
- 50
- 9.5
- 37
- 22.5
- 17.1
- 41
- 33.6

- 31.55
- 57.6
Topics covered: Solutions (answers)!

Access catheter and pump relationship
Roller pump failure and clotting
Substitution fluids
Venous ‘bubble trap’ chamber and clotting
Anticoagulation & recent research / findings
Training for CRRT
Vascular access catheters

- Inner and outer lumen: Coaxial
- Side by side: Double ‘D’
- Side by side: Double ‘O’
  D & O
Bard Niagara Vas-cath ®
Gambro Dolphin Protect ®
3 Key components to EC

Blood pump

Access catheter  Filter

Flow and Resistance
Roller pumps. Why they may **not deliver** the desired blood flow!

After forward compression, the tubing behind the rotating wheel will re-expand and refill with blood from the access catheter (A).

If patient access restricts flow, the tubing may not adequately refill and may remain partially collapsed. Output of the next pump stroke is reduced. Blood may also pass backwards through the occlusion gap before the compression stroke of the alternate wheel.

Flow reduction is therefore related to patient access, the revolutions per min. of the roller, (affecting refill time) the occlusion gap, and tubing reexpansion properties.

**Qb** backwards flow  
**Qf** forwards flow

Doppler ultrasound blood flow monitoring.

Schematic diagram of Doppler ultrasound transducer probe and bedside photo of the probe attached to CRRT blood line.
Compressed wave demonstrating flow reduction increasing in severity with time.

Figure 3.
Flow reduction identified in compressed wave view.

Flow reduction begins here.
Flow reduction period.
Peak flow 198 mls./min.
Trough flow 83 mls./min.

Filter clotted (D)
‘Mechanical’ failure

- 60% reduction in ‘life’ preceding OR following = ‘likely’ .....> 80% reduction....‘very likely’

Premature Circuit Clotting due to Likely Mechanical Failure during Continuous Renal Replacement Therapy

In Byung Kim, Nigel Fealy, Ian Baldwin, Rinaldo Bellomo
Department of Intensive Care Medicine, Austin Hospital, Melbourne, Vic., Australia

160 circuits

Fig. 1. Profile of circuit life in a single patient illustrating the application of the definition of MCF to our database.

1 in 8 mechanical failure
Different catheter lengths.....
Catheter placement to RA improves filter life?

A Randomized Trial of Catheters of Different Lengths to Achieve Right Atrium Versus Superior Vena Cava Placement for Continuous Renal Replacement Therapy

David Morgan, MBBS, FACEM, FCIIM
Kwok Ho, MBBS, FANZCA, FCIIM, MPH, PhD
Conor Murray, MBBS, FRANZCR
Hugh Davies, RN, BNurs, PostGrad Dip (Intensive Care), MMH, and
Jeanne Louw, MBBS, FRANZCR

Background: The aim was to assess whether inserting a longer soft silicone short-term dialysis catheter targeting tip placement in the right atrium could improve dialyzer circuit life span compared with inserting a shorter dialysis catheter targeting tip placement in the superior vena cava.

Study Design: Randomized, blinded, controlled study

Setting & Participants: A tertiary multidisciplinary intensive care unit enrolling 100 critically ill patients requiring continuous renal replacement therapy (CRRT).

Intervention: Placement of longer (20-24 cm) versus shorter dialysis catheters (15-20 cm) within one of the major thoracic veins for initiation of CRRT.

Outcomes: The primary study outcome was duration of dialysis circuit life span. Secondary outcomes included delivered daily dialysis dose, incidence and cause of CRRT circuit failure, complications potentially related to the position of the short-term dialysis catheter, mortality, and patient length of stay.

Results: Placing the longer dialysis catheters was associated with an increased average dialyzer life span of 6.5 hours (24 hours [25th-75th percentile, 11.32] vs 17.5 hours [25th-75th percentile, 9.22]; \( P = 0.001 \)), improved delivered daily dialysis dose (61% [25th-75th percentile, 56%-100%] vs 81% [25th-75th percentile, 72%-93%]; \( P < 0.001 \)), and reduced number of dialyzers clotted (2.3 vs 3.8; \( P = 0.04 \)) per patient compared with placing shorter dialysis catheters. The incidence of atrial arrhythmias was similar between groups (20% vs 21%; \( P = 0.6 \)) and the only mechanical complication was the malposition of one dialysis catheter tip in the longer dialysis catheter group.

Limitations: Single-center study design.

Conclusions: The use of longer soft silicone short-term dialysis catheters targeting right atrial placement appeared to be safe and could improve dialyzer life span and daily dialysis dose of CRRT delivered compared with the use of shorter catheters targeting superior vena cava placement.

Am J Kidney Dis 60(2):272-279, © 2012 by the National Kidney Foundation, Inc. Published by Elsevier Inc. All rights reserved.

INDEXWORDS: Catheters, right atrium, dialysis, renal replacement therapy, acute kidney injury, complications.
Morgan D, et al. AJKD, 60(2) 2012

Table 2. Outcomes of Patients by Intention-to-Treat Analysis

<table>
<thead>
<tr>
<th>Tip position of dialysis catheter</th>
<th>Longer Length (n = 47)</th>
<th>Shorter Length (n = 47)</th>
<th>Mean Difference Between Groups (95% CI)*</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right atrium</td>
<td>38 (81)</td>
<td>4 (9)</td>
<td>72% (55% to 83%)</td>
<td>0.001</td>
</tr>
<tr>
<td>Superior vena cava</td>
<td>9 (19)</td>
<td>43 (91)</td>
<td>−72% (−55% to −83%)</td>
<td></td>
</tr>
<tr>
<td>Primary outcome: dialyzer life span (h)</td>
<td>24.0 (21; 11-32)</td>
<td>17.5 (15; 8-23)</td>
<td>6.5 (1 to 11)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Dialysis parameters:
- Daily dialysis dose prescribed (mL/kg/h)*: 28.9 (21-35) vs 28.2 (23-33), 0.7 (−3 to 5), 0.7
- Daily dialysis dose delivered (mL/kg/h)*: 25.2 (19-31) vs 22.7 (15-23), 2.5 (−2 to 6), 0.2
- Dose of dialysis achieved (%)*: 91 (85-100) vs 81 (72-97), 10% (1% to 16%), 0.001
- No. of dialyzers needed during ICU stay*: 3.5 (3; 2-5) vs 5.0 (4; 2-6), −1.5 (−0.2 to −2.7), 0.03
- No. of dialyzers clotted per patient*: 2.3 (2; 0-9) vs 3.6 (3; 0-12), 1.3 (−0.3 to −2.4), 0.04
- No. of dialyzers & dialysis circuits taken down due to vascular access problem*: 0.2 (0; 0-3) vs 0.5 (0; 0-5), 0.3 (−0.1 to −0.7), 0.08
- No. of dialysis catheters required*: 1.1 (1; 1-1) vs 1.3 (1; 1-2), −0.2 (−0.3 to 0.1), 0.12
- Required a change in anticoagulation strategy: 1 (2) vs 7 (15), −13% (0% to 26%), 0.06

Mortality & length of stay:
- ICU mortality: 11 (23) vs 8 (17), 6% (−10% to 22%), 0.6
- Hospital mortality: 15 (32) vs 9 (19), 13% (−5% to 30%), 0.2
- Length of ICU stay (d)*: 6 [4-13] vs 10 [4-16], −5 (−13 to 2), 0.2
- Length of hospital stay (d)*: 26 [11-45] vs 37 [20-53], −12 (−30 to 6), 0.2

Figure 3. Kaplan-Meier survival curve of the life span of the dialyzer when the short-term dialysis catheter tip was placed at either the right atrium or superior vena cava. The time of the dialysis circuit taken down electively was censored in this analysis.
Fluids replacement in CRRT?

Predilution

Postdilution
Results support Pre-dilution

Pre-dilution

18 hrs
202

Post-dilution

13 hrs
107

P=0.0025

Filter life
hours

creatinine:  p=0.99
urea:  p=0.78

The venous chamber

Incidence of venous chamber clotting often the cause of circuit failure - ? 40 %
+ve pressure, gas, blood, fluids… mixing….

Different relationship to access catheter
Optimal design for chamber ?
Clot formation in venous air trap chamber
Current design

Vertical entry for blood IN

Level adjustment

Blood OUT via filter
New design - vortex

- Level adjustment
- Plasma water surface
- Side entry for blood IN
- Blood OUT via larger filter
- Reshaped profile here
‘Invivo testing’

Horizontal (Vortex)

Vertical
Pilot - Study

Adult ICU, CRRT patients with ARF
Cohort study, convenience sample, ethics approved

40 standard chamber, Vs 40 ‘Vortex’ design

CVVH 2 L/hr, all pre-dilution

No control for anticoagulation

Chamber manufactured by CL Plastics in Melbourne
Results: clotting score

More clotting

85% $\geq$ score of 3

P=0.50

Vertical

Horizontal

3.6 $\pm$ 1.03

3.8 $\pm$ 1.0

Blood Purification, 2012
Bubble Chamber Clotting during Continuous Renal Replacement Therapy: Vertical versus Horizontal Blood Flow Entry

Ian Baldwin\textsuperscript{a}  Nigel Fealy\textsuperscript{a}  Paula Carty\textsuperscript{a}  Martin Boyle\textsuperscript{b}  Inbyung Kim\textsuperscript{a}  Rinaldo Bellomo\textsuperscript{a}

\textsuperscript{a}Department of Intensive Care, Austin Hospital, Melbourne, Vic., and \textsuperscript{b}Department of Intensive Care, Prince of Wales Hospital, Sydney, N.S.W., Australia
Chamber clotting and post dilution?

No surface clotting!
Extended blood line entry

Anticoagulation


Low-Dose Heparinization for Anticoagulation in Intensive Care Patients on Continuous Hemofiltration

N. Gretz*, M. Quintel*, M. Ragaller†, W. Odenwälder*, H.J. Bender*, P. Rohmeiss*, M. Strauch*

Division of
* Nephrology and
† Anesthesiology, Klinikum Mannheim, University of Heidelberg, Mannheim, Germany

Contributions to Nephrology 1995, Vol. 116
So, use – Pre and post ‘dilution’......
Filter lifespan in critically ill adults receiving continuous renal replacement therapy: the effect of patient and treatment-related variables

Wendy J Dunn and Shyamala Sriram

Critical Care and Resuscitation • Volume 183 Number 3 • September 2014
Figure 2. Relationship between blood flow rate and filter lifespan

Table 4. Distribution of filters by vascular access site

<table>
<thead>
<tr>
<th>Site</th>
<th>Non-electively ceased filters* (n = 858)</th>
<th>All filters* (n = 1332)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left femoral</td>
<td>235 (27%)</td>
<td>376 (28%)</td>
</tr>
<tr>
<td>Left internal jugular</td>
<td>110 (13%)</td>
<td>180 (14%)</td>
</tr>
<tr>
<td>Left subclavian</td>
<td>13 (1%)</td>
<td>18 (1%)</td>
</tr>
<tr>
<td>Long term catheter</td>
<td>49 (6%)</td>
<td>83 (6%)</td>
</tr>
<tr>
<td>Right femoral</td>
<td>248 (29%)</td>
<td>387 (29%)</td>
</tr>
<tr>
<td>Right internal jugular</td>
<td>188 (22%)</td>
<td>260 (20%)</td>
</tr>
<tr>
<td>Right subclavian</td>
<td>15 (2%)</td>
<td>25 (2%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>0</td>
<td>3 (0.2%)</td>
</tr>
</tbody>
</table>

* No. of filters (% of total).
Methods: Heparin, Austin Hospital, Melbourne, Australia

Assess contraindications: (listed) → ? No AC

Prime: add heparin to priming fluid 5,000 IU

Bolus: 50 IU/kg

Infusion: 5-10 IU/kg/hr

Monitor: 6/24 APTT (60-85 sec.)

Filter life > 20 hrs

Alternative: is Heparin/Protamine or Citrate/Ca++
Filtrate

Citrate Replacement Fluids (14 mmol/L)

Calcium / Magnesium infusion to patient via CVC

CVVH - Citrate

PfiCa++; 0.3 – 0.5 mmol/L

Pre & Post

Filtrate
Start infusion at 4 mmol/hr (12 mls/hr)
Check after 1 hour
Ionised calcium < 0.9 mmol/L
Ionised calcium > 1.4 mmol/L
ICU registrar *

Ionised calcium 1.0 – 1.2 mmol/L
Maintain current infusion rate
Check ionised calcium after 6 hours
Check value of repeat ionised calcium measurement

Ionised calcium > 1.2 mmol/L
< 1.4 mmol/L
Decrease infusion by 0.5 mmol/hr (1.5 mls/hr)
Check ionised calcium after 1 hour

Ionised calcium < 1.0 mmol/L
> 0.9 mmol/L
Increase infusion at 0.5 mmol/hr (1.5 mls/hr)
Check ionised calcium after 1 hour
CVVHDF – Citrate, Complex
CVVH – Citrate, Simple

Pre (70 %) and Post (30%) CVVH citrate even better

Filter and V chamber
91+ hrs... pre-post Citrate CVVH

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real flow</td>
<td>200 ml/min</td>
</tr>
<tr>
<td>Desired flow</td>
<td>200 ml/min</td>
</tr>
<tr>
<td>UF flow</td>
<td>3300 ml/h</td>
</tr>
<tr>
<td>Weight Loss</td>
<td>300 ml/h</td>
</tr>
<tr>
<td>Treatment time</td>
<td>91:21</td>
</tr>
<tr>
<td>Weight variation</td>
<td>-17080 g</td>
</tr>
</tbody>
</table>

Infomed HF 440
Human – machine interface
Teaching in sequence …..Abstract to concrete…theory to practice

Theory

Simulation

Supervised experience
Know your own results: filter ‘life’

Anticoag. dose

<table>
<thead>
<tr>
<th>Filter hrs</th>
<th>On</th>
<th>Off</th>
<th>On</th>
<th>Off</th>
<th>On</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2, 3, 4, 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ICU CHART
Put filter /circuit life on your Radar
So what does it all mean Basil?
Frequent Clotting/consequences

Solute, acid base, electrolyte & fluid control (RRT)

Hrs of cont. function

20 – 30+

8 -20

0 -8

(No RRT) Anaemia Complications High cost

High cost
Summary – last slide.

- Clotting in the EC complex… e.g. liver failure
- Know your median ‘filter-life’ and compare (green zone, 20+ hrs)
- Circuit set-up and ‘mechanics’ important as anticoagulants
- Blood flow, blood flow, blood flow… !
- Simple anticoag protocol – develop expertise with this
- Staff training and education
Quality measures for acute kidney injury and continuous renal replacement therapy

Oleksa Rewa\textsuperscript{a}, Theresa Mottes\textsuperscript{b}, and Sean M. Bagshaw\textsuperscript{a}

Current Opinion in Critical Care, 2015, 21:6

KEY POINTS

- Quality and safety have become driving initiatives in the delivery of healthcare.
- Ensuring higher quality of care in AKI centers around risk identification, recognition, diagnosis, investigation, monitoring, and management.
- There is significant practice variation in the prescription of CRRT and this is an important measure of poor quality CRRT care.
- Future avenues of research will involve identifying and studying metrics on the prescription and delivery of high quality and safe CRRT care as well as incorporating simulation in CRRT educational programs.
Table 3. Median quantile regression with censored least absolute deviations analysis of filter circuit life and patient and treatment-related variables: non-electively ceased filter circuits

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Unadjusted coefficient (95% CI)</th>
<th>P</th>
<th>Adjusted coefficient (95% CI)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haemoglobin, g/dL</td>
<td>0.50 (−0.77, 1.76)</td>
<td>0.439</td>
<td>−0.77 (−1.18, −0.36)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Platelet, × 10^12/μL</td>
<td>−0.70 (−1.17, −0.22)</td>
<td>0.004</td>
<td>0.75 (0.51, 0.99)</td>
<td>0.002</td>
</tr>
<tr>
<td>International normalised ratio</td>
<td>0.45 (0.75, 1.66)</td>
<td>0.459</td>
<td>0.78 (0.22, 1.35)</td>
<td>0.016</td>
</tr>
<tr>
<td>Activated partial prothrombin time, s</td>
<td>−0.01 (−0.02, 0.02)</td>
<td>0.759</td>
<td>0.02 (−0.01, 0.05)</td>
<td>0.010</td>
</tr>
<tr>
<td>APACHE II score</td>
<td>0.06 (−0.01, 0.14)</td>
<td>0.101</td>
<td>0.02 (−0.01, 0.03)</td>
<td>0.110</td>
</tr>
<tr>
<td>APACHE III score</td>
<td>0.02 (−0.01, 0.03)</td>
<td>0.110</td>
<td>0.01 (−0.01, 0.03)</td>
<td>0.110</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>−0.50 (−1.88, 0.88)</td>
<td>0.478</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blood flow rate, units of 100 mL/min</td>
<td>3.33 (1.62, 5.05)</td>
<td>&lt;0.001</td>
<td>1.51 (0.09, 2.93)</td>
<td>0.037</td>
</tr>
<tr>
<td>Vascular catheter type</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Niagara</td>
<td>3.00 (1.49, 4.51)</td>
<td>&lt;0.001</td>
<td>2.48 (0.88, 4.08)</td>
<td>0.002</td>
</tr>
<tr>
<td>Arrowgard Blue</td>
<td>1.00</td>
<td></td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Cuffed long-term dual-lumen catheter</td>
<td>0.58 (−1.86, 3.02)</td>
<td>0.640</td>
<td>0.03 (−2.50, 2.56)</td>
<td>0.981</td>
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<tr>
<td>Vascular access site</td>
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<tr>
<td>Right internal jugular</td>
<td>1.75 (0.02, 3.48)</td>
<td>0.047</td>
<td>0.77 (−0.73, 2.27)</td>
<td>0.216</td>
</tr>
<tr>
<td>Left internal jugular</td>
<td>0.42 (−1.71, 2.54)</td>
<td>0.701</td>
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<tr>
<td>Right femoral</td>
<td>−0.50 (−1.60, 0.60)</td>
<td>0.372</td>
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<tr>
<td>Left femoral</td>
<td>−1.75 (−3.45, −0.05)</td>
<td>0.044</td>
<td>−1.04 (−2.43, 0.34)</td>
<td>0.141</td>
</tr>
<tr>
<td>Right subclavian</td>
<td>2.00 (−2.06, 6.05)</td>
<td>0.334</td>
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<tr>
<td>Left subclavian</td>
<td>−2.25 (−6.12, 1.62)</td>
<td>0.254</td>
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</tr>
<tr>
<td>Anticoagulation type</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enoxaparin</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regional heparin and protamine</td>
<td>0.75 (−1.03, 2.53)</td>
<td>0.408</td>
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<td></td>
</tr>
<tr>
<td>Anticoagulation type</td>
<td></td>
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<td></td>
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<tr>
<td>Regional heparin and protamine</td>
<td>1.00</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Low-dose heparin</td>
<td>0.00 (−3.15, 3.15)</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anticoagulation type</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regional heparin and protamine</td>
<td>1.00</td>
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</tr>
<tr>
<td>Heparin Infusion</td>
<td>1.92 (−0.30, 4.13)</td>
<td>0.090</td>
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</tr>
<tr>
<td>Anticoagulation type</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enoxaparin — all types</td>
<td>−1.67 (−3.12, −0.21)</td>
<td>0.025</td>
<td>−0.52 (−2.18, 1.13)</td>
<td>0.534</td>
</tr>
<tr>
<td>Other</td>
<td>−0.67 (−1.98, 6.34)</td>
<td>0.320</td>
<td>0.97 (−0.55, 2.48)</td>
<td>0.212</td>
</tr>
<tr>
<td>Nil</td>
<td>0.50 (−5.34, 6.34)</td>
<td>0.867</td>
<td>−0.52 (−6.79, 5.75)</td>
<td>0.871</td>
</tr>
</tbody>
</table>

APACHE = Acute Physiology and Chronic Health Evaluation.