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# Fluid Resuscitation after Cardiac Surgery in the Intensive Care Unit: A Bi-National Survey of Clinician Practice. (The FRACS-ICU Clinician Survey)

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## ABSTRACT

**Context and Aims:** To describe current fluid and vasopressor practices after cardiac surgery in Australia and New Zealand cardiothoracic intensive care units (ICU).

**Design and Setting:** This web-based survey was conducted in cardiothoracic ICUs in Australia and New Zealand.

**Methods:** Intensivists, cardiac surgeons, and anesthetists were contacted to complete the online survey that asked questions regarding first and second choice fluids and vasopressors and the tools and factors that influenced these choices.

**Results:** There were 96 respondents including 51 intensivists, 27 anesthetists, and 18 cardiac surgeons. Balanced crystalloids were the most preferred fluids (70%) followed by 4% albumin (18%) overall and among intensivists and anesthetists; however, cardiac surgeons (41%) preferred 4% albumin as their first choice. The most preferred second choice was 4% albumin (74%). Among vasopressors, noradrenaline was the preferred first choice (93%) and vasopressin the preferred second choice (80%). 53% initiated blood transfusion at a hemoglobin threshold of 70 g/L. Clinical acumen and mean arterial pressure were the most commonly used modalities in determining the need for fluids.

**Conclusions:** There is practice variation in preference for fluids used in cardiac surgical patients in Australia and New Zealand; however, balanced crystalloids and 4% albumin were the most popular choices. In contrast, there is broad agreement with the use of noradrenaline and vasopressin as first and second-line vasopressors. These data will inform the design of future studies that aim to investigate hemodynamic management post cardiac surgery.

**Keywords:** Albumin, cardiac surgery, critical care, fluids, transfusion, vasopressors

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## INTRODUCTION

Cardiac surgical operations are commonly performed, with approximately 13,000 operations per annum in Australia alone.<sup>[1]</sup> Cardiac surgery is one of the leading causes for

admission to an Intensive Care Unit (ICU) in Australia and New Zealand.<sup>[2]</sup> Intravenous fluids and vasoactive infusions are commonly used in the early peri-operative period in

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the ICU to improve cardiac output, blood pressure and organ perfusion.<sup>[3]</sup>

The evidence-base to guide the selection of fluid type and vasoactive drugs in this setting is not robust.<sup>[4]</sup> There are significant practice variations reported globally when it comes to selecting fluids and vasoactive drugs in the peri-operative period after cardiac surgery.<sup>[5,6]</sup> There is limited data on current practices in Australia and New Zealand.

We have designed the FRACS-ICU (Fluid resuscitation after cardiac surgery in the intensive care unit) Clinician Survey to describe current practices in Australia and New Zealand with regards to types of fluids used after cardiac surgery, types of vasopressor drugs used, tools used to determine the need for intravenous fluids, and endpoints used to titrate fluid and vasopressor therapy. The broader aim of the FRACS-ICU Clinician Survey is to inform the design of a multicenter randomized controlled trial of fluids and vasopressor therapy for patients after cardiac surgery.

## METHODS

### Study design

We conducted a survey of intensivists, cardiothoracic anesthetists, and cardiothoracic surgeons working in Australia and New Zealand hospitals where cardiac surgery is performed.

The entirely online, anonymous survey was hosted on Checkbox software [Checkbox Software Inc., MA, USA] provided by University of Queensland. It was disseminated via emails and newsletters from the College of Intensive Care Medicine of Australia and New Zealand, the Australia New Zealand Society of Cardiac and Thoracic Surgeons, the Australia New Zealand Intensive Care Society and by personally contacting unit directors and clinicians within the authors' networks.

This survey has been developed and reported using guidelines published by the Academic Medicine Journal<sup>[7]</sup> and the ACCADEMY<sup>[8]</sup> group.

### Study setting

This survey was coordinated from the ICU at The Prince Charles Hospital, QLD, Australia.

### Study population

Specialist ICU physicians, cardiac anesthetists, and surgeons who are regularly involved in the peri-operative care of patients post cardiac surgery in Australia and New Zealand.

### Survey design

FRACS-ICU was a custom designed survey based on the approach taken by previous similar surveys conducted in Europe<sup>[6]</sup> and North America.<sup>[5]</sup> The draft survey was tested by six clinicians, three from within (but not involved in the design of the questions) and three from outside the survey management committee for content, flow and administration. The survey was adapted iteratively based on tester feedback until the final version was produced (Supplement). The final survey was then pilot tested for administration prior to being disseminated.

Part 1 of the survey had nine questions on clinician and institutional demographics, mostly focused on individual and site volume of practice. Part 2 had thirteen questions on fluid and hemodynamic management. Participants were asked to assume that all questions related to their practice in the management of patients during the first 24 hours in ICU after cardiac surgery. Apart from clinician preferences for types of fluids (choices given were 0.9% sodium chloride, compound sodium lactate, Plasmalyte-148 (Baxter Healthcare Pty. Ltd.), 4% albumin, 20% albumin, blood products) and vasopressors (choices given were noradrenaline, adrenaline, vasopressin, dopamine, phenylephrine, metaraminol, other), there were also questions related to the tools clinicians used to determine the need for fluids, factors they considered when choosing a fluid or vasopressor, hemodynamic endpoints, and transfusion threshold. A free text field was provided at the end for participants to provide feedback to the survey management committee.

### Statistical analysis

Continuous data were summarized as median and interquartile range and categorical data as proportions. Being a descriptive survey, statistical analyses were not performed. Instead, results are presented graphically and as proportions.

### Ethical considerations

We obtained exemption from full ethics review from our Institutional Review Board (LNR/2018/QPCH/49169) for the conduct of this survey.

## RESULTS

### Response rate

The survey was opened by 237 respondents. One hundred and fourteen out of 237 respondents opened but did not start the survey. A further 27 started filling out the survey but did not complete it. This led to a final response rate of 41% (96 out of 237) of completed surveys, all of which were used in the analyses.

### Characteristics of respondents

Demographic information about respondents and their primary institution is presented in Table 1. Most respondents (n = 51, 53%) were intensivists. There were 27 cardiac anesthetists (28%) and 18 cardiothoracic surgeons (19%). Most respondents worked primarily in public hospitals (82%) and were based in the eastern states of Australia (84%). Only 6% of respondents were from New Zealand.

### Fluid management

The balanced crystalloid solutions, Plasmalyte-148 (39%) and Hartmann's solution (31%), were the most common first choice fluids [Table 2 and Figure 1] for fluid resuscitation after cardiac surgery. This was followed by 4% albumin (18%) and 0.9% saline (8%). When stratified by specialty, 89% of anesthetists and 79% of intensivists preferred a balanced crystalloid as compared to cardiac surgeons who preferred 4% albumin (41%) as their first choice. The most common second choice of fluid, i.e., the fluid that the respondent would administer after an adequate volume of the first-choice fluid has been administered, was 4% Albumin (74%) among all specialties.

Requirements for fluid resuscitation were most often determined by using clinical acumen (86%) and mean arterial pressure (80%). As described in Supplementary Figure 1, determinants used always or often by at least 50% of respondents included lactate, transoesophageal echocardiography appearances, heart rate, systolic blood pressure, transthoracic echocardiography appearances and drain output. Conversely, pulmonary capillary wedge pressure was rarely or never used by 43% of respondents. Other determinants that were rarely or never used were non-invasive cardiac output monitoring (37%), central venous oxygen saturation (36%), passive leg raise (34%), and mixed venous oxygen saturation (27%).

Risk of allergic reaction (66%), availability (60%), risks of bleeding (58%), and hyperchloremia (54%) were always or often considered by respondents when it came to selecting a fluid for resuscitation after cardiac surgery [Supplementary Figure 2]. On the other hand, anti-inflammatory and antioxidant properties of the fluid were rarely or never considered by 56% and 52% of respondents.

The blood transfusion hemoglobin threshold for patient not acutely bleeding was 70 g/L for most respondents (53%). By specialty [Table 3], 61% of

**Table 1: Characteristics of respondents and their institutions**

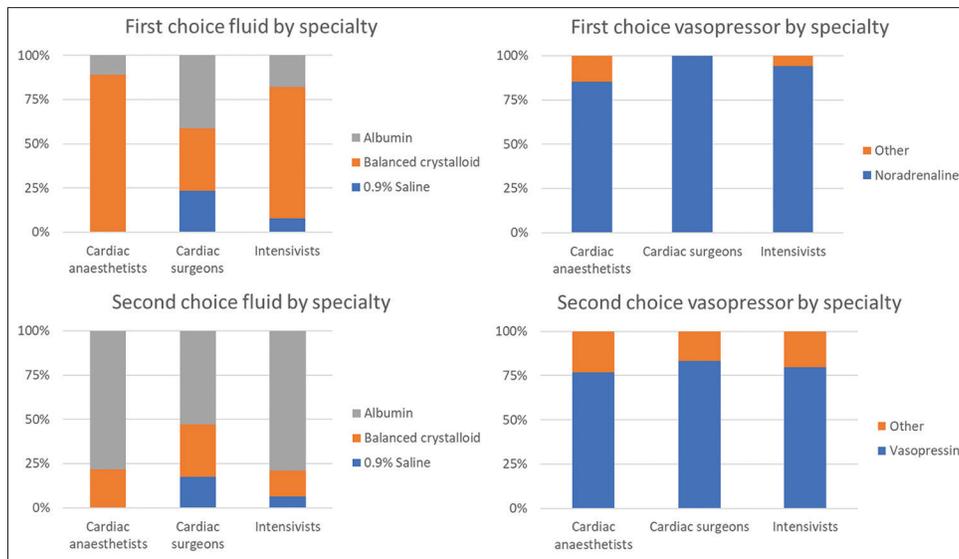
	n	%
Specialty		
Cardiac anesthetists	27	28
Cardiac surgeons	18	19
Intensivists	51	53
Hospital type		
Public	79	82
Private	5	5
Public-private combined	12	13
Number of acute hospital beds		
<400	15	16
400-599	35	36
600-799	36	38
>=800	10	10
Number of ventilator-equivalent ICU* beds		
<8	2	2
8-15	8	8
16-23	37	39
>=24	49	51
Number of cardiac surgical operations per annum		
<500	25	26
500-749	41	43
750-999	7	7
>1000	19	20
Incomplete	4	4
Country/state		
Australia		
Queensland	40	42
New South Wales	27	28
Victoria	12	13
Australian Capital Territory	1	1
South Australia	7	7
Western Australia	3	3
New Zealand	6	6

\*ICU - Intensive care unit

**Table 2: Fluid and vasopressor preferences**

	First preference fluid		Second preference fluid	
	n	%	n	%
0.9% Sodium chloride	8	8	6	6
20% Albumin	2	2	4	4
4% Albumin	17	18	60	63
Hartmann's solution	30	31	11	11
Plasma-Lyte 148	37	39	6	6
I do not use intravenous fluids for this indication	2	2	7	7
Other Blood Products	0	0	2	2
	First preference vasopressor		Second preference vasopressor	
	n	%	n	%
Norepinephrine	89	93	8	8
Vasopressin	0	0	74	77
Epinephrine	0	0	7	7
Dopamine	1	1	3	3
Metaraminol	5	5	1	1
Phenylephrine	1	1	0	0
Other	0	0	3	3

intensivists-initiated transfusion at hemoglobin of 70 g/L, compared to 44% of anesthetists and surgeons. 44% of surgeons and 41% of anesthetists-initiated transfusion at hemoglobin of 80 g/L.



**Figure 1:** Fluid and vasopressor preferences. This stacked column chart shows the first and second choice fluids and vasopressors by specialty

**Table 3: Blood transfusion hemoglobin thresholds**

Specialty	70 g/L	80 g/L	90 g/L	Other
Cardiac anaesthetists	12 (44%)	11 (41%)	2 (7%)	2 (7%)
Cardiac surgeons	8 (44%)	8 (44%)	1 (6%)	1 (6%)
Intensivists	31 (61%)	17 (33%)	2 (4%)	1 (2%)

### Vasopressor management

Noradrenaline was the first-choice vasopressor [Table 2 and Figure 1] across all specialties (93%). After an adequate dose of the first-choice vasopressor was administered, the most common second choice was vasopressin (80%), also across all specialties.

Factors that most commonly influenced vasopressor choice [Supplementary Figure 3] were vasopressor potency, arrhythmia potential and risk of causing tissue ischaemia. These factors were always or often considered when selecting a vasopressor by 72%, 68%, and 61% of respondents. Ability to use the vasopressor outside of an ICU setting (e.g., a surgical ward) was never or rarely considered by 68% of respondents.

### Other

Thirty-five percent of respondents indicated that they would initiate a fluid bolus at a MAP of 60-64 mm Hg and 32% at MAP of 55-59 mm Hg. Totally, 11% of respondents indicated they did not use MAP to determine initiation of fluid bolus. A total of 56% of respondents indicated that their target MAP range upon prescription of a fluid bolus was 65-69 mm Hg, with 16% targeting 60-64 mm Hg and 17% targeting >70 mm Hg. For patients who had been adequately fluid loaded and commenced on a vasopressor infusion, the preferred target MAP was 65-69 mm Hg for

66% of respondents and 60-64 mm Hg for 23%. 67% of respondents indicated that they used patients' baseline blood pressure in determining their MAP target.

### DISCUSSION

Our survey of fluid and vasopressor practices among clinicians involved in the care of patients after cardiac surgery shows that balanced crystalloid solutions are the most preferred first choice for fluid resuscitation overall. Albumin solutions were the most preferred second choice after an adequate volume of first choice fluid had been administered. Noradrenaline and vasopressin were the most common first and second choice vasopressors, respectively. Clinical acumen and MAP were most commonly used by clinicians in determining the need for fluid resuscitation.

There is practice variation in fluid choices, and determinants of the need for fluid administration, after cardiac surgery in Australia and New Zealand, including differences in preferences between intensivists, anaesthetists, and cardiac surgeons. While there is high-quality evidence in the general critical care literature pertaining to synthetic colloids,<sup>[9,10]</sup> albumin<sup>[11,12]</sup> and balanced crystalloids,<sup>[13,14]</sup> in the cardiac surgical population, data are limited to small trials with physiological endpoints and retrospective data.<sup>[15]</sup> Interestingly, there was little variation in preferences for vasopressors. Noradrenaline was overwhelmingly the first choice followed by vasopressin, despite some randomized trial evidence that vasopressin use, compared to noradrenaline, may result in lower morbidity<sup>[16,17]</sup> in cardiac surgical patients. Overall, the major implication of these findings is that further research with patient-centered outcomes is required to guide fluid and vasopressor choices

in the peri-operative management of cardiac surgical patients.

With regards to transfusion thresholds, most respondents used an evidence-based threshold of 70 g/L.<sup>[18]</sup> There were a large proportion of anaesthetists and surgeons who transfused at a higher threshold of 80 g/L, possibly due to the different timepoints during the patient journey at which they may be involved in making a transfusion decision.

There are two recently published surveys, one each from Europe and United States of America (USA), which are comparable to our survey in terms of methodology and sample size. The major methodological differences between our survey and these two surveys are that we also collected data on vasopressor choices, did not survey perfusionists (though some of the anaesthetist respondents may have been perfusionists also) and did not collect data on intra-operative fluid use and cardiopulmonary bypass priming. Major global variations in fluid preferences among practitioners exist. In Europe, the most preferred first-choice fluid is balanced crystalloid, followed by crystalloid and synthetic colloid combination and crystalloid-albumin combination. In the USA, crystalloid was the most preferred first-choice fluid followed by 5% albumin and then 25% albumin.

This is the first survey investigating fluids and vasopressor choices after cardiac surgery in Australian and New Zealand. The survey methodology was robust and based on published guidelines. Dissemination was broad and targeted all relevant practitioners. The data presented will be useful for researchers planning studies evaluating fluid and vasopressor use in the cardiac surgical population. However, there were also several limitations. The response rate of opened surveys was 41%, which is in keeping with rates observed in the medical literature.<sup>[19]</sup> Nonetheless, sampling bias cannot be excluded given this response rate. The survey was designed to be short and easy to complete, but this meant that detailed questions exploring the full depth and breadth of issues that affect fluid and vasopressor selection were lacking. Large proportions of respondents worked in large hospitals with large ICUs and a high volume of cardiac surgery. Therefore, respondents from smaller institutions and lower volume of surgery may be underrepresented with resultant sampling bias.

## CONCLUSIONS

In cardiac surgical patients requiring fluid resuscitation in the ICU, balanced crystalloids are the preferred choice of fluid overall, though most cardiac surgeons preferred 4%

albumin. Noradrenaline was the preferred vasopressor among all respondents, with vasopressin the second choice. Most respondents used clinical acumen and MAP to determine the need for fluid resuscitation. Given the practice variations described and the relative paucity of high-quality evidence, further research evaluating fluids and vasopressors in cardiac surgical patients is warranted.

## Financial support and sponsorship

Nil.

## Conflicts of interest

There are no conflicts of interest.

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## SURVEY QUESTIONS

### Part 1: Demographics

This section asks questions about you and your institution.

1. What is your primary specialty i.e., the specialty in which you do the majority of your clinical practice?
  - Cardiothoracic Surgery
  - Cardiothoracic Anesthesia
  - Intensive Care Medicine
2. How many years have you been a consultant in your primary specialty in Australia and/or New Zealand?  
\_\_\_\_\_years
3. What sort of hospital do you primarily work in?
  - Public
  - Private
  - Public-private combined
4. How many acute beds does your hospital have approximately?
  - Less than 400
  - 400-599
  - 600-799
  - Greater than or equal to 800
5. How many ventilator equivalent beds does your ICU typically have?
  - Less than 8
  - 8-15
  - 16-23
  - Greater than or equal to 24
6. How many cardiac surgical operations requiring post-operative Intensive Care Unit (ICU) admission are performed in your hospital per annum?
  - Less than 500
  - 500-749
  - 750-999
  - Greater than or equal to 1000
7. If you are an anaesthetist, approximately how many cardiac surgical operations do you anaesthetise for per year?  
\_\_\_\_\_years
8. If you are a surgeon, approximately how many cardiac surgical operations do you perform per year?  
\_\_\_\_\_years
9. In which country, state or territory is your hospital located?
  - ACT
  - NSW
  - NZ
  - QLD
  - SA
  - TAS
  - VIC
  - WA

### Part 2: Fluid and haemodynamic management in the ICU

The next thirteen questions focus on haemodynamics, fluids and blood product management in the first 24 hours in ICU after cardiac surgery. Please assume that all questions apply to your practice in the management of patients in the first 24 hours after cardiac surgery.

10. How useful do you consider the following tools and signs to be when determining the need for intravenous fluid resuscitation?

Use the following scale: 1 = not useful 2 = rarely useful 3 = sometimes useful 4 = often useful 5 = always useful

- Systolic blood pressure
- Mean arterial pressure
- Heart rate
- Central venous pressure (CVP)
- Central venous saturation (ScvO<sub>2</sub>)
- Mixed venous saturation (SmvO<sub>2</sub>)
- Pulmonary capillary wedge pressure (PCWP)
- Pulse pressure variation
- Systolic pressure variation
- Stroke volume variation
- Transthoracic echocardiography
- Transoesophageal echocardiography
- Non-invasive cardiac output monitoring
- Passive leg raise test
- Urine output
- pH
- Lactate
- Mediastinal drain output
- Clinical acumen

11. If you were to use blood pressure to determine the need for fluids, at what mean arterial pressure would you typically consider an intravenous fluid bolus?

- 50-54 mm Hg
- 55-59 mm Hg
- 60-64 mm Hg
- 65-69 mm Hg
- Other
- I do not use intravenous fluids for this indication

12. Do you use the patient's baseline blood pressure in determining blood pressure targets after cardiac surgery?

- Yes
- No

13. What is your preferred target mean arterial pressure range for patients after cardiac surgery?

- Less than 55 mm Hg
- 55-59
- 60-64
- 65-69 mm Hg
- Greater than 70 mm Hg
- I do not target a mean arterial pressure range

14. Which of the following type of fluids is your first choice for a patient who you have determined to require volume expansion but is not experiencing significant blood loss?

- 4% Albumin
- 20% Albumin
- 0.9% Sodium chloride
- Compound sodium lactate (Hartmann's Solution)
- Plasma-Lyte 148
- Blood products (other than albumin)

- I do not use intravenous fluids for this indication

15. Which of the following type of fluids is your second choice after you have administered an adequate volume of your first choice in a patient not experiencing significant blood loss?

- 4% Albumin
- 20% Albumin
- 0.9% Sodium chloride
- Compound sodium lactate (Hartmann's Solution)
- Plasma-Lyte 148
- Blood products (other than albumin)
- I do not use intravenous fluids for this indication

16. Which of the following factors do you consider to be important when selecting the type of fluid for patients after cardiac surgery?

Use the following scale: 1 = not at all important 2 = somewhat important 3 = moderately important 4 = very important 5 = extremely important

- Oncotic properties
- Avoid hyperchloraemic metabolic acidosis
- Avoid risk of allergic reaction
- Cost
- Ease of availability
- Endothelial preservation
- Anti-oxidant properties
- Avoid risk of bleeding
- Anti-inflammatory properties

**For Questions 17 to 22, please assume that the patient has normal or near-normal myocardial function and has had adequate volume loading.**

17. What is your preferred management strategy for the adequately volume loaded hypotensive patient who is not experiencing significant blood loss?

- More intravenous fluid
- Vasopressor infusion
- Other

18. Which of the following factors do you consider to be important when selecting vasopressors for patients after cardiac surgery?

Use the following scale: 1 = not at all important 2 = somewhat important 3 = moderately important 4 = very important 5 = extremely important

- Vasopressor potency
- Inotropic potency
- Chronotropic potency
- Propensity for tachyarrhythmia
- Propensity for lactaemia
- Propensity for ischaemic complications
- Concerns about graft integrity
- Ability to use in non-ICU setting

19. If you were to commence a vasopressor infusion as specified in Question 15, what mean arterial pressure range do you target?

- 50-54 mm Hg
- 55-59 mm Hg

- 60-64 mm Hg
- 65-69 mm Hg
- Other
- I do not use vasoactive infusions in this setting

20. Which of the following vasopressors is your first choice for a patient who has had adequate volume loading and is not experiencing significant blood loss or tamponade?

- Adrenaline
- Dopamine
- Metaraminol
- Noardrenaline
- Phenylephrine
- Vasopressin
- Other

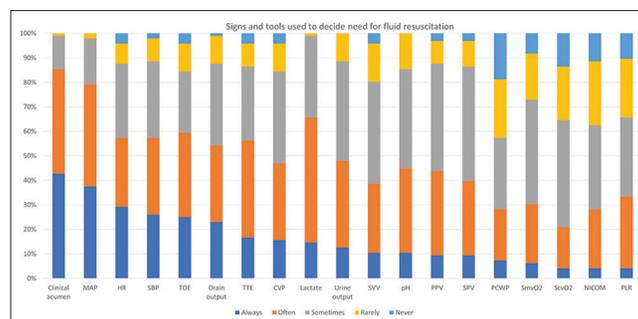
21. Which of the following vasoactive agents is your preferred adjunct for an adequately fluid loaded patient who is already receiving a sufficient dose of your first choice vasopressor and is not experiencing significant blood loss or tamponade?

- Adrenaline
- Dopamine
- Metaraminol
- Noradrenaline
- Phenylephrine
- Vasopressin
- Other

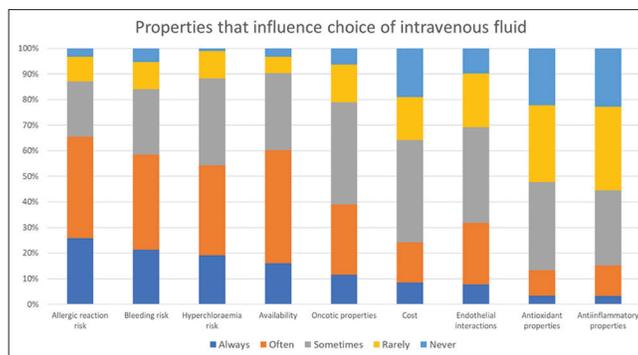
22. What is your haemoglobin threshold for initiating packed red cell transfusion?

- 70 g/L
- 80 g/L
- 90 g/L
- 100 g/L
- Other

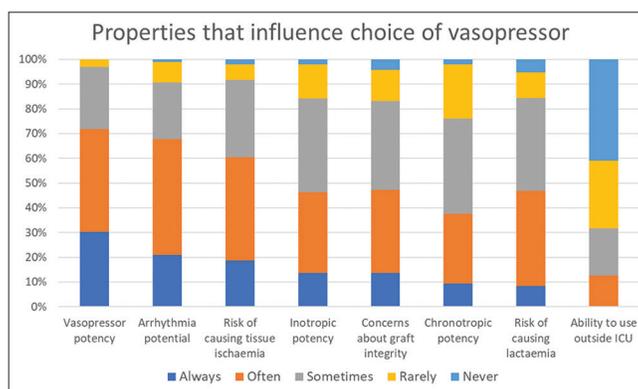
This is the end of the survey. If you have any comments regarding fluids and vasoactive infusions after cardiac surgery, please type them in the space provided.



**Supplementary Figure 1:** This stacked column chart shows how frequently respondents used the listed signs and tools to determine the need for fluid resuscitation. MAP- mean arterial pressure; HR- heart rate; SBP- systolic blood pressure; TOE- transoesophageal echocardiography; TTE- transthoracic echocardiography; CVP- central venous pressure; SVV- stroke volume variation; PPV- pulse pressure variation; SPV- systolic pressure variation; PCWP- pulmonary capillary wedge pressure; SmvO2- mixed venous oxygen saturation; ScvO2- central venous oxygen saturation; NICOM- non-invasive cardiac output monitoring; PLR- passive leg raise



**Supplementary Figure 2** The stacked column chart shows how frequently the listed properties of fluids were taken into account by respondents when determining their choice of intravenous fluid for fluid resuscitation



**Supplementary Figure 3:** The stacked column chart shows how frequently the listed properties of vasopressors were taken into account by respondents when determining their choice of vasopressor

This Excel file contains data used to create Figure 1.

Please note that Figure is created as a stacked percentage chart in Excel.

	First preference fluid			First preference vasopressor			
	Cardiac anaesthetists	Cardiac surgeons	Intensivists	Cardiac anaesthetists	Cardiac surgeons	Intensivists	
0.9% Saline	0	4	4	Norepinephrine	23	18	48
Balanced crystalloid	24	6	37	Other	4	0	3
Albumin	3	7	9	Second preference vasopressor			
	Second preference fluid			Second preference vasopressor			
	Cardiac anaesthetists	Cardiac surgeons	Intensivists	Vasopressin	Cardiac anaesthetists	Cardiac surgeons	Intensivists
0.9% Saline	0	3	3	Other	20	15	39
Balanced crystalloid	5	5	7		6	3	10
Albumin	18	9	37				