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Authors
McIlroy, David R
Roman, Bennett
Billings, Frederic T
et al.

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Original Article

Potential Renoprotective Strategies in Adult Cardiac Surgery: A Survey of Society of Cardiovascular Anesthesiologists Members to Explore the Rationale and Beliefs Driving Current Clinical Decision-Making

David R. McIlroy[*,†,1], Bennett Roman[‡], Frederic T. Billings IV[*], Bruce A. Bollen[§], Amanda Fox[‖], Mariya Geube[¶], Hong Liu[#], Linda Shore-Lesserson[**], Alexander Zarbock[††], Andrew D. Shaw[‡‡]

[*]*Vanderbilt University Medical Center, Nashville, TN*
[†]*Monash University, Commercial Road, Melbourne, Victoria, Australia*
[‡]*Ochsner Medical Center, New Orleans, LA*
[§]*Missoula Anesthesiology and The International Heart Institute of Montana, Missoula, MT*
[‖]*UT Southwestern Medical Center, Dallas, TX*
[¶]*Cleveland Clinic, Cleveland, OH*
[#]*University of California Davis Health, Sacramento, CA*
[**]*Zucker School of Medicine at Hofstra Northwell, Manhasset, NY*
[††]*University Hospital Münster, Münster, Germany*
[‡‡]*University of Alberta, Edmonton, AB, Canada*

Objectives: The authors sought to (1) characterize the rationale underpinning anesthesiologists' use of various perioperative strategies hypothesized to affect renal function in adult patients undergoing cardiac surgery, (2) characterize existing belief about the quality of evidence addressing the renal impact of these strategies, and (3) identify potentially renoprotective strategies for which anesthesiologists would most value a detailed, evidence-based review.
Design: Survey of perioperative practice in adult patients undergoing cardiac surgery.
Setting: Online survey.
Participants: Members of the Society of Cardiovascular Anesthesiologists (SCA).
Interventions: None.
Measurements & Main Results: The survey was distributed to more than 2,000 SCA members and completed in whole or in part by 202 respondents. Selection of target intraoperative blood pressure (and relative hypotension avoidance) was the strategy most frequently reported to reflect belief about its potential renal effect (79%; 95% CI: 72-85). Most respondents believed the evidence supporting an effect on renal injury of intraoperative target blood pressure during cardiac surgery was of high or moderate quality. Other factors, including a specific nonrenal rationale, surgeon preference, department- or institution-level decisions, tradition, or habit, also frequently were reported to affect decision making across queried strategies. Potential renoprotective strategies most frequently requested for inclusion in a subsequent detailed, evidence-based review were intraoperative target blood pressure and choice of vasopressor agent to achieve target pressure.
Conclusions: A large number of perioperative strategies are believed to variably affect renal injury in adult patients undergoing cardiac surgery, with wide variation in perceived quality of evidence for a renal effect of these strategies.

[1]Address correspondence to David R. McIlroy, Department of Anesthesiology, Vanderbilt University Medical Center, 1211 21st Ave S, Nashville, TN 37212.
E-mail address: david.r.mcilroy@vumc.org (D.R. McIlroy).

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Key Words: perioperative; thoracic surgery; acute kidney injury

ACUTE KIDNEY injury (AKI) is a major complication after cardiac surgery, typically occurring in 20%-to-30% of patients, and is associated with increased length of stay, cost, development of chronic kidney disease and mortality.[1-5] Many strategies have been suggested to potentially mitigate perioperative AKI.[6,7] However, the growing number of studies reporting on such strategies, with marked variation in study quality, impact, and reproducibility, makes it challenging for the busy anesthesiologist to be confident that their practice reflects best available evidence for perioperative renal protection. As part of its commitment to patient safety, quality, and education, the Society of Cardiovascular Anesthesiologists (SCA) currently is developing a Continuing Practice Improvement (CPI) document to help busy anesthesiologists maintain a robust, evidence-based inventory of strategies aimed at providing renal protection in clinical practice for adult patients undergoing cardiac surgery.

The complexity of perioperative clinical decision-making has been described.[8] For the cardiac anesthesiologist, decision-making may involve cognitive integration of the available scientific evidence for a strategy's impact on multiple (potentially competing) organ systems, together with resource availability, existing beliefs, practice patterns or culture, and more. Currently, there is little known about the rationale behind clinical decision-making for specific practice strategies hypothesized to affect perioperative renal function, the level of certainty that clinicians believe supports the renal effect of such strategies, and specific renoprotective strategies for which anesthesiologists would most value an up-to-date, evidence-based review.

The objective of the current survey was to inform and focus the SCA's forthcoming CPI document reviewing perioperative renoprotective strategies so that it best meets the needs of members. Specific aims of the survey were to (1) characterize the rationale underpinning anesthesiologists' use of various perioperative strategies hypothesized to affect renal function, (2) characterize existing belief about the quality of evidence currently addressing the renal impact of these strategies, and (3) identify specific strategies for which SCA members would most value a detailed, evidence-based review to update their perioperative renoprotective effort in adult patients undergoing cardiac surgery.

Materials and Methods

In line with SCA policy, the survey was approved by the research committee of the SCA for distribution to SCA members. After reviewing a description of the proposed survey plan, including a copy of planned survey questions, the institutional review board of Vanderbilt University Medical Center deemed the research exempt from further institutional review board review.

Survey Development

A 17-question survey was developed for online administration via the Research Electronic Data Capture platform by members of the SCA's CPI Acute Kidney Injury Working Group. The first 11 questions each were presented in two parts, designated A and B, as multiple-choice questions with, seven and five response options, respectively. These questions sought to identify (1) the rationale underlying current clinical decision-making for strategies hypothesized to affect perioperative AKI, and (2) the level of scientific evidence that clinicians believe supports the effect on renal injury of each strategy, as a measure of the certainty with which they currently practice. The intraoperative strategies addressed by these 11 questions were drafted by one member of the AKI Working Group (D.R.M.) and then reviewed and modified through an iterative process involving other AKI Working Group members to include the following: intraoperative use of volatile anesthetic agents, administered fraction of inspired oxygen (F_IO_2), target blood pressure and specific vasopressors used to manage hypotension, use of chloride-rich (*v* buffered) intravenous (IV) fluid solutions, erythrocyte transfusion threshold, glycemic management strategy, alpha-2 agonist administration, IV steroid administration, diuretic administration in the context of oliguria, and use of a goal-directed algorithm for oxygen delivery while on cardiopulmonary bypass (CPB). Each of these strategies, applied in some form during the perioperative period, has been evaluated previously in observational studies or clinical trials for an association with AKI after cardiac surgery.[9-19] The order of presentation of response options for questions one-to-11A was varied randomly, while response options for questions one-to-11B were presented in a consistent and logically ordered sequence. For each of questions one-to-11A, more than one response could be selected, while for questions one-to-11B only one response could be selected (Fig 1). Question 12 asked respondents to select up to five potentially renoprotective strategies from a suite of 16 options for which they would most value a detailed, evidence-based review. The options included each of the strategies presented in questions one-to-11, as well as several additional potential renoprotective strategies (the Kidney Disease: Improving Global Outcomes [KDIGO] bundle of care,[20] remote ischemic preconditioning, the time interval from cardiac catheterization and contrast exposure to cardiac surgery, prophylactic administration of sodium bicarbonate, and the use of adjunctive regional anesthesia/analgesia). Questions 13-to-16 sought to characterize the respondent's geographic region of practice, level of training, and type and volume of cardiac anesthesia practice via finite multiple-choice responses, while question 17 invited any free-text comments on the survey. Start time and end time of participation were recorded, allowing calculation of time taken to complete the survey. No personal

A. Response options for questions that sought to understand the reasons underpinning current clinical decision making for perioperative strategies that may potentially impact AKI[a]

My decision about …. (specific clinical strategy) …. during adult cardiac surgery reflects, at least in part: (multiple responses permitted)
a) My belief regarding the potential renal effects of the specific perioperative strategy
b) Another specific (but non-renal) rationale
c) Practice dictated by resource availability
d) Institutional or departmental decision or policy
e) Surgical preference within my institution
f) Tradition/habit
g) Other

B. Response options for questions that sought to characterize the level of scientific evidence that clinicians believe support the clinical decisions being asked about, as a measure of the certainty with which they currently practice.

In my opinion current evidence to support an effect on renal injury of ……. during anesthesia for adult cardiac surgery is (one response only):[b]
a) high quality (effect estimate unlikely to change with further research)
b) moderate quality (effect estimate likely to change with further research)
c) low or very-low quality (effect estimate very likely to change with further research)
d) I am not sure of the quality of the current evidence
e) other

Fig 1. Response options for questions one-11 A and B of the survey.

information was collected nor were incentives to participate offered. After clicking the hyperlink to accept the invitation to participate, 17 questions then were presented over 13 screens to all respondents. Progress to each subsequent screen of questions was achieved by clicking a button labeled "Next Page." Answering the questions on a given screen was not required to advance to the next screen; after advancing to each subsequent screen, there was no opportunity to return to a previous screen to review or modify answers. Prior to distribution to the entire SCA membership, the survey first was piloted among members of the SCA's 2020-2021 Quality and Safety Leadership Committee and members of the CPI-AKI Working Group, testing survey usability, functionality, and timing, and inviting specific feedback via the final question of the survey or via direct email to the one of the investigators (D.R.M.). A limited response (n = six) confirmed functionality, with no changes suggested as a result of this testing.

Survey Distribution

The survey was distributed via email by SCA administrative personnel to the SCA membership on June 23, 2020 (Supplemental Digital Content 1). E-mail blasts were repeated on July 7 and July 21, 2020 irrespective of previous response status. A fourth and final email was sent July 28, 2020, with the aim of increasing the number of respondents. In each case, the email provided a brief description of the purpose of the survey, emphasizing the voluntary nature of participation and the anticipated time required for completion, and requesting that members complete the survey only once. No additional techniques were used to prevent or detect duplicate responses. Final responses were collected for analysis on August 5, 2020.

Statistical Analysis

Final survey response data were downloaded from Research Electronic Data Capture on August 5, 2020 as a .csv file and imported into Stata 12 (Stata Corporation, College Station, TX) for subsequent analysis. Analysis was predominantly descriptive, with counts and proportions provided for responses to each question, and then stratified according to practice type, level of training, and caseload, with use of the chi-square statistic or Fisher exact test. For each question, the number of respondents providing a response to that question constituted the denominator for the purposes of analysis, with data from all available responses included for analysis of each question unless otherwise stated. P values < 0.05 were considered statistically significant. Reporting of the survey results was guided by the CHEcklist for Reporting Results of Internet E-Surveys.[21]

Results

Survey Response Metrics

The email invitation to participate was sent successfully to 3,152, 2,092, 2,082, and 2,070 email addresses on the four dates described above (Supplemental Digital Content 2). The survey was entered on 260 occasions and completed, in whole or in part, by 202 respondents. Fifty-eight participants did not provide any responses to survey questions after entering the survey platform and were not included in further analysis. Median (interquartile range) time to complete the survey was eight (six-12) minutes. Of respondents who provided demographic details, 65% (n = 106) were based in academic or university practice, with the remainder in private practice; 85% (n = 141) were from North America; 73% (n = 120) had completed training that included a cardiothoracic anesthesia fellowship, 26% (42) had completed training that did not include a cardiothoracic anesthesia fellowship, and 1% (n = two) were currently in training. Finally, during a typical year, 47% of respondents reported providing anesthesia for >100 patients, 44% provide anesthesia for 50-to- 100 patients, and 10% provide anesthesia for <50 patients undergoing cardiac surgical procedures (Fig 2, A-D).

Renal Rationale for Using Various Strategies

Across each of the 11 strategies queried, the proportion of respondents reporting that multiple rationale influenced their clinical decision-making for any given strategy ranged from 35%-to-63%. The perioperative strategy most frequently reported to reflect respondent belief about the renal effect of the strategy was selection of intraoperative target blood pressure range (79%; 95% CI: 72-85) (Table 1). The hemoglobin threshold for erythrocyte transfusion was reported to reflect belief about renal effects of transfusion and anemia by 63% (95% CI: 55-70) of respondents, while 54% (95% CI: 47-62) and 50% (95% CI: 42-58) reported that their choice of whether to use a chloride-rich or buffered IV fluid and whether or not to administer a diuretic to prevent or treat oliguria, respectively, reflected their belief about the renal effect of these strategies. Choice of specific vasopressor to treat intraoperative hypotension (43%; 95% CI: 35-50), use of a protocol for goal-directed delivery of O_2 while on CPB (40%; 95% CI: 32-48), intraoperative glucose management strategy (37%; 95% CI: 29-45), and selection of intraoperative F_IO_2 (35%; 95% CI: 28-42) each were reported to reflect belief about the renal effect of these strategies by more than one-third of respondents, while the choice of whether or not to use alpha-2 agonist agents (25%; 95% CI: 19-32), intraoperative steroids (25%; 95% CI: 18-32), and administration of a volatile anesthetic agent (18%; 95% CI: 13-24) were reported less frequently, to reflect respondent belief about the renal effect of these strategies. With the exception of volatile anesthetic agent administration, these responses did not vary according to type of practice, fellowship training or case volume (Supplemental Digital Content 3, Table 1).

Respondent-Perceived Level of Evidence for a Renal Effect of Various Strategies

Almost 80% of respondents stated that, in their opinion, the evidence supporting an effect on renal injury of target intraoperative blood pressure during cardiac surgery was of high (n = 46; 25% [95% CI: 19-31]) or moderate (n = 101; 54% [95% CI: 47-61]) quality (Table 2). More than half of respondents reported that the quality of evidence supporting an effect on renal injury of the hemoglobin threshold used to guide erythrocyte transfusion was moderate (n = 99; 58% [95% CI: 50-65]), while 17% (95% CI: 12-23; n = 30) and 14% (95%

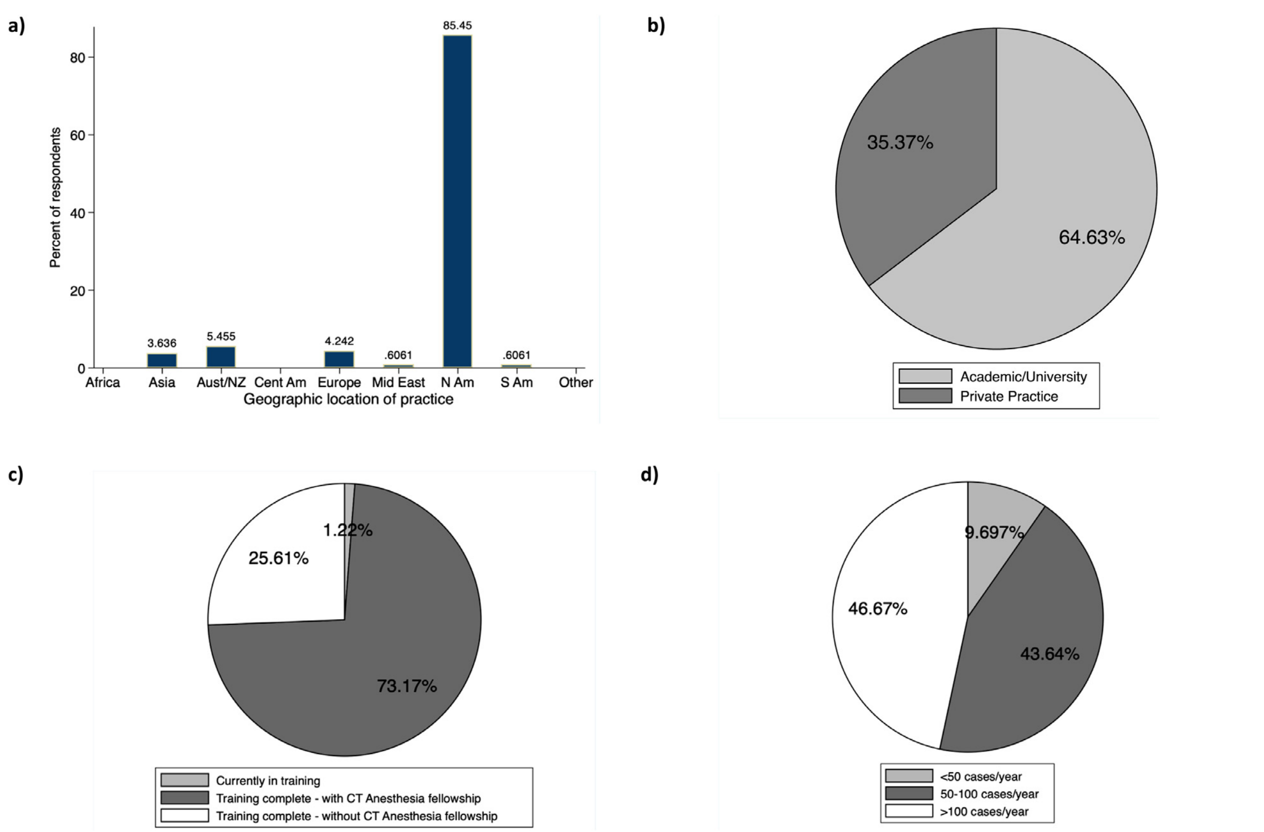

Fig 2. Respondent demographics by (A) geographic location of practice, (B) type of practice, (C) level of training, and (D) annual case volume of cardiac surgical procedures.

Table 1
Rationale for Clinical Decision Making for Strategies That Might Affect Perioperative Renal Injury

Potentially Renoprotective Strategy	Rationale for Clinical Decision Making n % (95% CI)*							
	No. of Respondents (N)	Potential Renal Effects (%)	Another Specific (but Nonrenal) Rationale (%)	Tradition or Habit (%)	Department/ Institutional Decision or Policy (%)	Resource Availability (%)	Surgical Preference (%)	Other (%)
Q1. Use of a (specific) volatile anesthetic agent	200	N = 36 18 (13-24)	N = 71 36 (29-43)	N = 106 53 (46-60)	N = 54 27 (21-34)	N = 59 30 (23-36)	N = 12 6 (3-10)	N = 9 5 (2-8)
Q2. Intraoperative F_IO_2	192	N = 67 35 (28-42)	N = 115 60 (53-67)	N = 77 40 (33-47)	N = 14 7 (4-12)	N = 3 2 (0-4)	N = 6 3 (1-7)	N = 6 3 (1-7)
Q3. Intraoperative target blood pressure range	186	N = 147 79 (72-85)	N = 79 42 (35-50)	N = 35 19 (13-25)	N = 24 13 (8-19)	N = 6 3 (1-7)	N = 61 33 (26-40)	N = 2 1 (0-4)
Q4. Chloride-rich vs buffered IV fluid	181	N = 98 54 (47-62)	N = 55 30 (24-38)	N = 55 30 (24-38)	N = 46 25 (19-32)	N = 30 17 (11-23)	N = 20 11 (7-17)	N = 8 4 (2-9)
Q5. Specific vasopressor for intraoperative hypotension	174	N = 74 43 (35-50)	N = 89 51 (43-59)	N = 67 39 (31-46)	N = 28 16 (11-22)	N = 34 20 (14-26)	N = 54 31 (24-38)	N = 9 5 (2-10)
Q6. Hb threshold for erythrocyte transfusion	172	N = 108 63 (55-70)	N = 87 51 (43-58)	N = 34 20 (14-27)	N = 46 27 (20-34)	N = 21 12 (8-18)	N = 66 38 (31-46)	N = 7 4 (2-8)
Q7. Intraoperative alpha-2 agonist	171	N = 43 25 (19-32)	N = 90 53 (45-60)	N = 37 22 (16-29)	N = 42 25 (18-32)	N = 31 18 (13-25)	N = 23 13 (9-19)	N = 17 10 (6-15)
Q8. Intraoperative IV steroid	170	N = 42 25 (18-32)	N = 88 52 (44-59)	N = 34 20 (14-27)	N = 33 19 (14-26)	N = 3 2 (0-5)	N = 50 29 (23-37)	N = 14 8 (5-13)
Q9. Protocol for goal-directed O_2 delivery on CPB	165	N = 66 40 (32-48)	N = 51 31 (24-39)	N = 43 26 (20-33)	N = 35 21 (15-28)	N = 15 9 (5-15)	N = 58 35 (28-43)	N = 10 6 (3-11)
Q10. Diuretic to prevent/ treat oliguria	165	N = 83 50 (42-58)	N = 52 32 (25-39)	N = 44 27 (20-34)	N = 20 12 (8-18)	N = 7 4 (2-9)	N = 45 27 (21-35)	N = 17 10 (6-16)
Q11. Intraoperative glucose management	166	61 37 (29-45)	89 54 (46-61)	34 20 (15-27)	107 64 (57-72)	10 6 (3-11)	37 22 (16-29)	6 4 (1-8)

Abbreviations: CPB, cardiopulmonary bypass; F_IO_2, fraction of inspired oxygen; Hb, hemoglobin; IV, intravenous.
* Proportion (95% CI) calculated using the number of respondents to each specific question (1-11A) as the denominator.

Table 2
Clinician Perceived Level (Quality) of Evidence for a Renal Effect of Various Perioperative Strategies

	Clinician Perceived Level (Quality) of Evidence for a Renal Effect of Various Perioperative Strategies					
	% (95% CI)*					
	N	High	Moderate	Low or Very Low	Unsure	Other
Q1 (Specific) volatile anesthetic agent	202	0 (0-1)	15 (10-20)	43 (36-50)	41 (34-48)	0 (0-1)
Q2 F_IO_2	192	2 (0-3)	21 (15-27)	31 (25-38)	46 (39-53)	-
Q3 Target intraoperative BP	186	25 (19-31)	54 (47-61)	13 (9-18)	8 (4-11)	-
Q4 Chloride content of IV fluid	181	18 (12-23)	41 (34-48)	20 (15-26)	20 (15-26)	1 (0-2)
Q5 Vasopressor agent	176	10 (6-15)	36 (29-43)	37 (30-44)	16 (11-22)	-
Q6 Transfusion threshold	172	17 (12-23)	58 (50-65)	14 (9-19)	11 (6-16)	-
Q7 Alpha-2	171	6 (2-9)	20 (14-26)	32 (25-39)	41 (34-48)	1 (0-3)
Q8 Steroid	170	10 (5-15)	11 (6-16)	41 (34-49)	35 (28-42)	2 (0-5)
Q9 Goal-directed O_2 delivery protocol on CPB	165	10 (6-15)	33 (26-41)	24 (17-30)	32 (25-39)	1 (0-2)
Q10 Diuretic	166	12 (7-17)	30 (23-37)	38 (31-45)	19 (13-25)	1 (0-2)
Q11 Glycemic management strategy	166	27 (20-34)	39 (32-47)	20 (14-26)	13 (8-18)	1 (0-2)

Abbreviations: BP, blood pressure; CPB, cardiopulmonary bypass; F_IO_2, fraction of inspired oxygen; IV, intravenous.
* Proportion (95% CI) calculated using multinomial logistic regression

CI: 9-19; n = 24) believed the quality of evidence for such an effect was high, and low or very low, respectively. For the IV administration of chloride-rich versus buffered crystalloid solution, the most frequent belief was that the quality of evidence supporting an effect of chloride-rich fluid on renal injury was moderate (41%; 95% CI: 34-48 [n = 74]), but included a spread from high-quality (18%; 95% CI: 12-23 [n = 32]) to low- or very-low-quality (20%; 95% CI: 15-26 [n = 37]), as well as explicit uncertainty about the quality of evidence (20%; 95% CI: 15-26 [n = 37]). More than a quarter (27%; 95% CI: 20-34 [n = 45]) of respondents believed there to be high-quality evidence supporting an effect on renal injury from intraoperative glycemic management in adult patients undergoing cardiac surgery, while a further 39% (95% CI: 32-47; n = 65) of respondents reported the quality of evidence for an effect on renal injury from such a strategy to be moderate. Explicit uncertainty about the quality of evidence supporting an effect on renal injury from selection of intraoperative F_IO_2, intraoperative volatile anesthetic administration, and intraoperative dexmedetomidine, was reported by 46% (95% CI: 39-53; n = 89), 41% (95% CI: 34-48; n = 83), and 41% (95% CI: 34-48%; n = 70) of respondents, respectively. There was weak evidence that belief regarding the quality of evidence supporting an effect of intraoperative target blood pressure on renal injury may vary between respondents in academic practice and private practice (Supplemental Digital Content 3, Table 2). For all other interventions queried, belief about the level of evidence supporting an effect on renal injury from these strategies did not vary according to type of practice (academic *v* private) nor whether or not respondents had completed a cardiothoracic anesthesia fellowship as part of their training.

Nonrenal Rationale for Using Various Strategies

A specific nonrenal rationale also was reported frequently to influence clinical practice decisions across queried perioperative strategies. More than half of respondents reported the influence of such factors in their selection of intraoperative F_IO_2, intraoperative glucose management, steroid, and alpha-2 agonist administration; choice of specific vasopressor to treat hypotension; and selection of a hemoglobin threshold to trigger erythrocyte transfusion. Tradition or habit was reported most frequently to influence use of a volatile anesthetic agent (53%; 95% CI: 46-60), followed by selection of intraoperative F_IO_2 (40%; 95% CI: 33-47) and the specific vasopressor used to treat intraoperative hypotension (39%; 95% CI: 31-46); other strategies were reported less frequently (19-30) to be influenced by habit. Department- or institution-level decisions were reported most frequently to influence intraoperative glycemic management strategy (64%; 95% CI: 57-72). Surgeon preference was reported most frequently to influence choice of hemoglobin threshold for erythrocyte transfusion (38%; 95% CI: 31-46), use of a protocol for goal-directed oxygen delivery during CPB (35%; 95% CI: 28-43), as well as selection of both an intraoperative target blood pressure range (33%; 95% CI: 26-40) and specific vasopressor agent used to treat hypotension (31%; 95% CI: 24-38). Resource availability was reported to influence a decision regarding volatile anesthetic agent use by 30% (95% CI: 23-36) of respondents but had much less influence (2%-20%) on other decisions (Table 1).

Perioperative Strategies Requested for Evidence-Based Review

When asked to nominate potentially renoprotective strategies for which respondents would most value a detailed, evidence-based review, intraoperative target blood pressure (65%; 95% CI: 57-72), and choice of specific vasopressor agent (61%; 95% CI: 53-68) were the most frequently selected responses, followed by intraoperative hemoglobin threshold for erythrocyte transfusion (39%; 95% CI: 32-47), goal-directed delivery of O_2 while on CPB (38%; 95% CI: 31-46), the KDIGO bundle of care[20] (34%; 95% CI: 27-42), and intraoperative use of dexmedetomidine (33%; 95% CI: 26-41) (Fig 3).

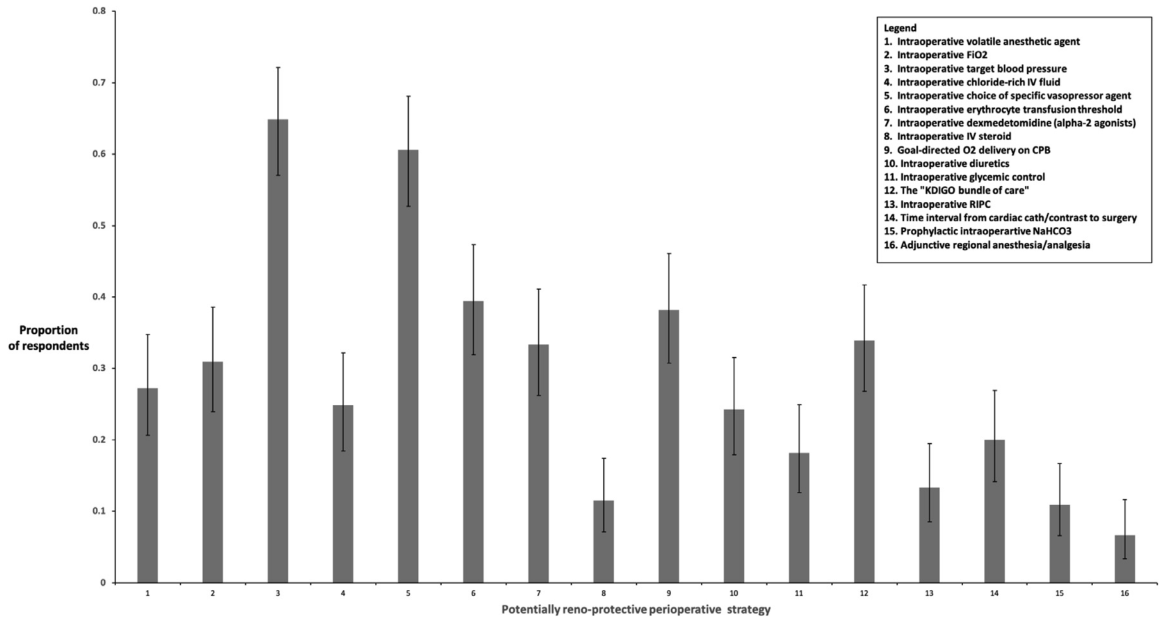

Fig 3. Renoprotective strategies (proportion of respondents and 95% CIs) for which respondents would most value a detailed evidence-based review.

Discussion

The authors surveyed the SCA's membership seeking to (1) characterize the rationale underpinning anesthesiologists' use of 11 perioperative strategies hypothesized to affect perioperative renal injury, (2) characterize existing belief about the quality of evidence currently addressing the renal impact of these strategies, and (3) seek direction from the membership as to which potentially renoprotective perioperative strategies they would most value through a detailed, evidence-based review from the SCA's CPI Working Group for AKI.

Selection of an intraoperative target blood pressure (79%; 95% CI: 72-85), hemoglobin threshold for erythrocyte transfusion (63%; 95% CI: 55-70), choice of chloride-rich versus buffered IV fluid solution (54%; 95% CI: 47-62), and whether or not to administer a diuretic to prevent or treat oliguria (50%; 95% CI: 42-58) were the perioperative strategies for which clinical decision-making most frequently reflected a respondent's belief about the renal effect of such strategies. For every strategy queried, the most common belief regarding the quality of evidence supporting the strategy's effect on perioperative renal injury was "moderate," "low or very low," or "unsure," the first two responses both consistent with a belief that the current effect estimate for the intervention is likely to change with further research. Intraoperative target blood pressure and specific choice of vasopressor agent, followed by the hemoglobin threshold for erythrocyte transfusion, goal-directed O_2 delivery on CPB, the KDIGO bundle of care recommended in the KDIGO AKI guidelines,[20] and use of alpha-2 agonists, such as dexmedetomidine, were the perioperative strategies for which a detailed review of the evidence most frequently was requested.

For every one of the 11 strategies queried in this survey, at least some respondents (range: 18%-79%) reported that their clinical decision-making reflected, at least in part, a belief about the potential renal effect of the strategy. This suggested remarkable breadth of strategies currently employed with renoprotective intent by members, together with a lack of consensus among respondents for any single perioperative strategy to affect renal injury. This survey also suggested the integration of multiple factors to influence the use of specific strategies hypothesized to affect perioperative renal injury. Across each of the 11 strategies queried, 35%-to- 63% of respondents reported that at least two factors influenced their clinical decision-making, supporting the multifaceted nature of these decisions and suggesting influence from beyond the anesthesiologist's evaluation of specific patient factors. Surgeon preference was reported by approximately one-third of respondents to influence intraoperative target blood pressure, hemoglobin threshold for erythrocyte transfusion, and use of a protocol for goal-directed O_2 delivery on CPB. More than half of respondents reported the influence of an institutional or departmental policy on their intraoperative glycemic strategy. These findings supported the significance of stakeholders beyond the anesthesiologist in existing patterns of practice and the potential challenges associated with driving practice change, even when evidence-based, within a complex system.[22]

For most perioperative strategies queried, there was marked variation in the perceived quality of evidence supporting an effect of the strategy on perioperative renal injury and, in some cases, this appeared significantly misaligned with existing data. A quarter of respondents reported the quality of evidence supporting an effect of intraoperative target blood pressure on renal injury was high, while more than half reported the evidence for such an effect to be of moderate quality. In fact, there are limited observational data supporting an association between lower intraoperative blood pressure and postoperative AKI in patients undergoing cardiac surgery. Three randomized trials have reported renal outcomes when testing the effect of a higher compared to lower target blood pressure in patients undergoing cardiac surgery. In each case, the higher target blood pressure was implemented during CPB only, with no evidence of a renoprotective effect,[9,23,24] supporting the findings of a recent Consensus Conference on cardiac surgery−associated AKI that there were insufficient data to guide a recommendation for intraoperative target blood pressure.[25] Although there was a high level of explicit uncertainty about the quality of evidence supporting an effect of intraoperative F_IO_2, choice of volatile agent, and intraoperative dexmedetomidine on renal injury, almost a quarter of respondents believed the quality of evidence supporting an effect of intraoperative glycemic management strategy on renal injury to be high, while a further one-third believed it to be of moderate quality. Most of the trial data evaluating the impact of glycemic management strategy come from a critical care context, typically comparing so-called tight glucose control to more conventional thresholds of treatment, with mixed results and uncertain generalizability to the intraoperative period.[20] A single-center randomized trial of tight (target 80-100 mg/dL) versus conventional (target <200 mg/dL) intraoperative glucose control conducted in 371 patients undergoing cardiac surgery, noted an increased stroke risk in the intensive therapy group but no difference in renal injury between groups.[26] A recent meta-analysis identified two further small randomized trials of intraoperative glycemic management strategy in cardiac surgery addressing renal outcomes, failing to identify any renal effect of the strategy.[7] Understanding the reason for wide interindividual differences in perceived level of evidence associated with various strategies is beyond the scope of the current survey. Large volumes of constantly evolving evidence, together with the clinical research expertise required for correct interpretation of often conflicting clinical studies, may both contribute. Most importantly, it highlights the potentially valuable role for regularly updated CPI documents from professional bodies such as the SCA, succinctly summarizing the existing evidence (and areas of ongoing uncertainty) to support up-to-date and evidence-based practice by clinicians.

Respondents provided clear indication that the potential renoprotective role of intraoperative target blood pressure and the agent(s) used to achieve target blood pressure are of great interest. Despite limited evidence to inform these important questions, a concise summary of the currently available evidence will be an essential component of the forthcoming AKI CPI document. Based on the results, the evidence for any renoprotective effect of varied erythrocyte transfusion strategies, goal-directed O_2 delivery on CPB, the KDIGO bundle of care,[20] and alpha-2 agonists, such as dexmedetomidine, also will require concise review to provide user-oriented and evidence-based recommendations to members.

Limitations

The response rate to the survey was lower than previous surveys of the SCA membership that were conducted using similar methodology.[27-29] This had a modest impact on the precision of estimates from the sample (maximal 95% CI: ±8%, compared to ±4% with 500 respondents) but did limit the opportunity for meaningful subgroup exploration. Previous authors have emphasized the greater importance of response representativeness over actual response rate.[30] Nonresponder bias is an inherent risk to all surveys and difficult to evaluate. Pragmatic suggestions to explore for evidence of such bias include comparing the demographics of respondents with the known demographics of the target population.[31] Demographics of respondents to the current survey (academic *v* private practice, case volume, level of training and geographic location) appear broadly comparable to that reported by a selection of previously published surveys of the SCA membership, supporting the absence of identifiable nonresponder bias within these domains.[27-29] Anesthesiologists have been affected variably by the coronavirus disease 2019 pandemic, including increased workload with high-risk exposure for some, and a decreased workload for others.[32] It remains unknown if and how this disruption may have affected response rates. Additionally, survey fatigue may have contributed to the reduced response rate. A recent survey of Canadian physician specialists identified survey burden and lack of time for completion as the main reason for initial survey nonresponse.[33] The SCA membership was surveyed at least seven times during 2020, and likely more often if non-SCA survey requests also were able to be considered. Finally, the list of perioperative strategies queried by the survey was not comprehensive. Other strategies (eg, remote ischemic preconditioning, atrial natriuretic peptide, the KDIGO bundle of care[34-36]) have been investigated for a potential renoprotective effect and the results may not be generalizable to these strategies. However, the authors sought to include strategies with broad availability, applicability, and contemporary relevance, together with a pragmatic requirement to limit survey length to minimize incomplete responses.[31] Despite these limitations, the current survey provided valuable information to focus the forthcoming CPI document on potential renoprotective perioperative strategies of greatest interest to the SCA membership.

In summary, the authors confirmed the large number of perioperative strategies currently and variably believed to affect perioperative renal injury for adult patients undergoing cardiac surgery, as well as wide variation in the perceived quality of evidence for the effect of these strategies on perioperative renal injury. The authors also identified potential renoprotective perioperative strategies for which members would most value a detailed, evidence-based review to guide their practice. This information will aid in focusing the forthcoming CPI document from the SCA's AKI Working Group to best meet the clinical decision-making needs of members.

Conflict of Interest

Drs. McIlroy and Shore-Lesserson are members of the editorial board of the *Journal of Cardiothoracic and Vascular Anesthesia*. One of the authors (Dr A. Fox) is supported by an NIH grant that needs to be acknowledged/declared in association

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Supplementary materials

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