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Why physicians use sodium bicarbonate during cardiac arrest: A cross-sectional survey study of adult and pediatric clinicians

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ABSTRACT

Background: Despite recommendations against routine use, sodium bicarbonate (SB) is administered in approximately 50% of adult and pediatric in-hospital cardiac arrest (IHCA).
Methods: Cross-sectional electronic survey of adult and pediatric attending physicians at two academic hospitals in Boston, Massachusetts. The survey included two IHCA vignettes. Additional open- and closed-ended items explored clinician beliefs surrounding intra-arrest SB and perspectives on a hypothetical clinical trial comparing SB with placebo.
Results: Of the 356 physicians invited, 224 (63 %) responded. Of these, 54 (24 %) said they would "probably" or "definitely give" SB in Scenario 1 (10-minute asystolic arrest) compared to 110 (49 %) for Scenario 2 (20-minute asystolic arrest; $p < 0.001$). The most frequently reported indications for SB were: hyperkalemia (78 %); metabolic acidosis (76 %); tricyclic anti-depressant overdose (71 %); and prolonged arrest duration (64 %). Of the 207 (92 %) respondents who reported using intra-arrest SB in at least some circumstances, the most common reasons for use were: "last ditch effort" in a prolonged arrest (75 %) and belief that there were physiologic benefits (63 %). When asked of the importance of a clinical trial to guide intra-arrest SB use, 188 (84 %) respondents felt it was at least of average importance, and 140 (63 %) said they would be "somewhat" or "very comfortable" enrolling patients in a trial comparing SB and placebo in IHCA.
Conclusions: Physicians reported practice variations surrounding cardiac arrest management with SB. Respondents commonly cited metabolic acidosis and prolonged arrest duration as indications for intra-arrest SB, despite not being supported by the American Heart Association's advanced life support guidelines.

Introduction

In the United States, in-hospital cardiac arrest (IHCA) occurs in approximately 292,000 adults and 15,200 children per year [1], with hundreds of thousands more experiencing out-of-hospital cardiac arrest (OHCA)[2]. In addition to basic cardiopulmonary resuscitation (CPR), administration of medications is central to the management of cardiac arrest. Sodium bicarbonate (SB) is a physiologic buffer that can mitigate the progressive acidosis that occurs during CPR[3]. While early animal trials conducted based on this rationale were promising[4–8],

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subsequent work in animals [9–14] and humans [15–24] has shown mixed results, leading the American Heart Association (AHA) to recommend against the routine administration of SB in pediatric and adult cardiac arrest, with the exceptions of hyperkalemia and certain drug toxicities [25,26].

Despite these guidelines, contemporary estimates show that SB is used in about 50 % of both pediatric and adult IHCA, making it the second most used drug during IHCA, after epinephrine [27,28]. Given this apparent discrepancy between guidelines and practice, we sought to explore clinician beliefs surrounding intra-arrest SB administration by conducting a cross-sectional survey study amongst clinicians most likely to manage IHCA. We hypothesized that SB use would vary by specialty, and that indications for intra-arrest SB *not* endorsed by AHA guidelines would be common. Secondarily, we aimed to explore clinician attitudes toward a hypothetical clinical trial surrounding intra-arrest SB.

Methods

The Boston Children's Hospital Institutional Review Board determined that this study was exempt on March 29th, 2023 (IRB-P00043851).

Survey development

After literature review to identify possible practice variation surrounding intra-arrest SB administration, authors (CER, MMH, AMS) iteratively developed an initial survey according to best practices of survey design [29]. Cognitive interviews with 7 physicians of differing specialties were conducted consisting of "think-aloud" discussions and probing techniques for each survey item to minimize response error and maximize clarity and comprehension.[30]. Additional pilot testing was performed to ensure survey functionality was preserved.

The final survey consisted of 6 to 7 close-ended items and 1 to 4 open-ended items. The total number of items was determined by branching logic based on respondent selections. The first two survey questions employed a clinical vignette of asystolic IHCA in a previously healthy patient with pneumonia and normal laboratory values prior to arrest. Respondents were asked how likely they were to administer SB at 10 and 20 min of CPR, respectively. Following these, an open-ended item asked the respondents to describe circumstances in which they would or would not use SB during cardiac arrest (i.e. indications/contraindications) and the reasons behind these practice decisions. Branching logic was used to direct respondents to the appropriate closed-ended items addressing the same topics. These items were only viewable after the open-ended response was completed to avoid leading the clinicians' initial open-ended response. Additionally, a hypothetical clinical trial comparing SB and placebo during IHCA was presented. Respondents were asked how comfortable they would be enrolling patients in the trial, and open-ended items were provided to solicit suggestions on how they might alter the study design. Finally, 9 demographic questions were included as well as an option to provide contact information for participation in future research on the topic (Supplemental File 1).

Population and data collection

Adult and pediatric emergency medicine (EM), intensive care unit (ICU) and anesthesia attendings at two institutions in Boston, Massachusetts, were invited to participate in the survey. Eligibility criteria included full-time hospital-based physicians working at least 50 % clinical time at the primary institution. A database of eligible participants was created through personal contact with colleagues for each specialty.

Survey distribution and data collection were performed with REDCap (Vanderbilt University, Nashville, TN). Invitations to participate were sent via email with unique, anonymous survey links on October 3rd, 2023. Reminders for those who had not responded were sent periodically until the goal of > 60 % response rate was reached on December 15th, 2023.

Analysis

Descriptive statistics are presented as counts with relative frequencies, medians and interquartile ranges (IQRs). The distribution of Likert-type scale responses in Scenarios 1 and 2 were compared using a Chi-squared test. To compare respondent characteristics with likelihood of giving intra-arrest SB, the Likert-type scale responses to Scenarios 1 and 2 were dichotomized to reflect those who would "probably" or "definitely" give SB versus those who would not give SB or were unsure. Participant characteristics for those who would or would not give SB for each scenario were compared using Fisher's exact test for categorial variables and Cochran–Armitage test for trend for ordinal variables. Quantitative analyses were performed with Stata (v17, StataCorp, College Station, TX).

For the open-ended items, we performed qualitative thematic analysis using framework analytic method.[31,32]. Authors CER and JLS independently reviewed all open-ended responses and created preliminary codes. These were iteratively discussed and refined during team meetings. The finalized codes were linked to the raw data using Dedoose software [33], and themes were identified. These themes were iteratively discussed and reconciled during subsequent team meetings. Trustworthiness was ensured by having two researchers, a pediatrics resident and a pediatric ICU attending who were familiar with the topic perform the analysis, as well as having two additional team members, one clinical (MMH) and one non-clinical (AMS), review the codes.

Results

Of the 356 physicians invited to participate, 224 (63 %) completed the survey. Respondent characteristics are listed in Table 1.

Likert-type scale responses for likelihood of giving SB in Scenario 1 (10-minute asystolic arrest) and Scenario 2 (20-minute asystolic arrest) are shown in Fig. 1. The distribution of these responses differed significantly between the two scenarios ($p < 0.001$), with 54 of 224 (24 %) respondents said they would "probably" or "definitely give" SB in Scenario 1 and 110 (49 %) for Scenario 2. Of the 105 participants who would not have given SB for either scenario, 88 (84 %) reported that they would consider SB in other circumstances.

Circumstances for giving SB

Overall, the most reported indications for giving intra-arrest SB were: hyperkalemia (78 %); metabolic acidosis (76 %) with a median reported threshold pH of 7.1 (IQR: 7, 7.2); tricyclic anti-depressant overdose (71 %); and prolonged arrest duration (64 %) with a median reported threshold of 15 min (IQR: 10, 20) (Table 2).

In addition to the clinical circumstances listed in the quantitative section of the survey, the following themes emerged in the open-ended responses (quotes are identified by respondent number):

1. Ventilation: Respondents reported using intra-arrest SB with the caveat that the patient could be adequately ventilated.

   "Patients noted to be significantly acidemic prior to their arrest, with the ability to adequately ventilate." R68
   "If I think acidosis caused the arrest and we may be able to effectively clear CO2, I am more likely to give bicarbonate." R32

2. Arrest rhythm: Some clinicians favored giving SB for a particular arrest rhythm (asystole, ventricular fibrillation, etc.) over others, though each arrest rhythm was invoked by different respondents.

Table 1
Baseline characteristics of survey respondents.

Characteristic	N = 224
Residency Training	
Anesthesia	90 (40)
Emergency Medicine	23 (10)
Internal Medicine	24 (11)
Internal Medicine/Pediatrics	6 (3)
Pediatrics	98 (44)
Other	4 (2)
Fellowship Training	
Adult Cardiology	1 (0.5)
Adult Pulmonary/Critical Care Medicine	22 (10)
Anesthesia Critical Care Medicine	18 (8)
Emergency Medicine Critical Care Medicine	5 (2)
Surgical Critical Care Medicine	0 (0)
Pediatric Anesthesia	50 (22)
Pediatric Cardiology	6 (3)
Pediatric CICU (1 year)	9 (4)
Pediatric Critical Care Medicine	60 (27)
Pediatric Emergency Medicine	36 (16)
Other	15 (7)
None	26 (12)
Patient Population	
Majority Adult (>75 %)	81 (36)
Majority Pediatric (>75 %)	142 (63)
Mixed Pediatric/Adult	1 (1)
Practice Location	
Adult Emergency Department	21 (9)
Adult Operating Room	37 (17)
Adult ICU	35 (16)
Pediatric Emergency Department	38 (17)
Pediatric Operating Room	50 (22)
Pediatric ICU	60 (27)
Type of Pediatric ICU	**N = 60**
Cardiac ICU	22 (37)
Non-cardiac ICU	42 (70)
Mixed ICU	4 (7)
Type of Adult ICU	**N = 35**
Cardiac ICU	6 (17)
Cardiac Surgery ICU	10 (29)
Medical ICU	25 (71)
Mixed Medical/Surgical ICU	19 (54)
Surgical or Trauma ICU	10 (29)
Neuro ICU	6 (17)
Years in Practice	
0-<3 years	46 (21)
3- <5 years	19 (8)
5- <10 years	47 (21)
10 to < 15 years	25 (11)
15 to < 20 years	33 (15)
20 or more years	54 (24)
Certifications	
BLS	193 (86)
ACLS	178 (79)
ATLS	46 (21)
NRP	18 (8)
PALS	162 (72)
None	3 (1)
Average number of code events in a 12 month period	
0	11 (5)
1–2	73 (33)
3–5	64 (29)
6–10	34 (15)
11–15	26 (12)
16 or more	16 (7)

Abbreviations: CICU, cardiac intensive care unit; ICU, intensive care unit; BLS, basic life support; ACLS, advanced cardiovascular life support; ATLS, advanced trauma life support; NRP, neonatal resuscitation program; PALS, pediatric advanced life support.

"[Pulseless Electrical Activity], asystole may respond better than shockable rhythm." R150
"Refractory VF" R171
"[Wide complex tachycardia] of unclear etiology" R108

3. Other specific diagnoses: Prior to viewing the pre-specified options in the closed-ended survey questions, respondents listed many of the same diagnoses in their free-text responses. In addition to these options, respondents reported several other specific diagnoses for which they would prioritize giving SB. The most common of these were renal failure, cardiac disease and other specific toxidromes. A list of all specified diagnoses is provided in Supplemental Table 1.

"Renal failure patient on dialysis as they cannot buffer themselves." R127
"Arrest in congenital heart disease or primary cardiac origin." R105

Reasons for using intra-arrest SB

Of the 207 (92 %) respondents who reported using intra-arrest SB in at least some circumstances, the most commonly cited reasons for using intra-arrest SB included: use as a "last ditch effort" in a prolonged arrest (75 %); belief that there were physiologic benefits to treating intra-arrest acidosis with SB (63 %); and belief that SB is a low-risk intervention (43 %) (Table 2). Only 30 (14 %) respondents indicated that their use of intra-arrest SB was consistent with AHA guidelines.

Open-ended responses for reasons to give intra-arrest SB had significant overlap with the pre-specified quantitative options. New themes included:

1. Peer pressure: Some clinicians reported feeling pressure from other team members to administer intra-arrest SB.

"Pressure from other members of care team (usually nursing) to perform some intervention beyond CPR/epinephrine –- the sense that pushing more meds will be more helpful." R164
"I also give it if someone else suggests it, and I feel there's not something more important to do, as I want the team to feel satisfied with our resuscitation efforts. Residents, nurses, RTs, techs, everyone knows you can give bicarb during a code, so a lot of times people suggest it." R97
"No data – somewhat peer pressure honestly. I generally favor never giving bicarbonate …" R55

2. Hs and Ts: Many respondents viewed acidosis (H + ion) as a reversible cause of cardiac arrest warranting treatment with SB.

"I would consider giving bicarb … as one aspect of dealing with H's and T's. In this case, specifically to address acidosis." R35
" … acidosis may have contributed to arrest and could be a reversible cause." R164

Reasons to avoid intra-arrest SB

For the 17 (8 %) respondents who said they would not consider intra-arrest SB use in any circumstances, common reasons for avoidance included: adherence to cardiac arrest guidelines (47 %); concerns for intra-cellular acidosis (35 %); and associations of intra-arrest SB with poor outcomes in prior research (35 %) (Table 2). Open-ended responses revealed concerns for SB contributing to respiratory acidosis.

"Concern for the development of respiratory acidosis in this circumstance, which is worse than metabolic acidosis since CO2 – bicarb bi-product – is likely to be worse than metabolic acidosis." R147.

Theories on physiologic mechanisms of intra-arrest SB

In addition to the physiologic mechanisms listed in the quantitative item options, respondents proposed alternative theories for why SB may be physiologically harmful or helpful during cardiac arrest.

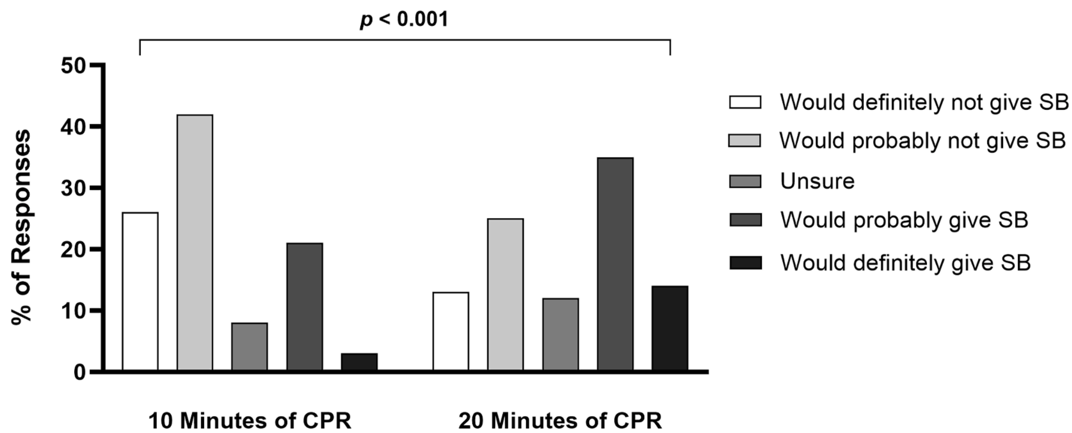

Fig. 1. Likert-type responses for likelihood of administering sodium bicarbonate in Scenario 1 (10-minute asystolic arrest) and Scenario 2 (20-minute asystolic arrest).

> "It can additionally act as a fluid load" R19
> "I would always give bicarb, understanding the detrimental acidosis effect on enzyme function." R233
> "[For] sodium channel blockade (e.g. TCA overdose), I would definitely give sodium bicarb (for the sodium, not the bicarb)." R69
> "I generally favor *never* giving bicarbonate because I feel that acidosis enhances oxygen delivery from hemoglobin." R55

Practice differences by respondent characteristics

Differences in the likelihood of giving SB in Scenarios 1 and 2 existed according to respondent characteristics (Table 3). The proportion of respondents who would "probably" or "definitely give" SB in Scenario 1 varied based on practice location ($p = 0.025$), with the lowest proportion in the pediatric and adult ED settings (8 % and 10 %, respectively) and the highest amongst those working in an adult ICU (38 %). While the proportion of respondents reporting that they would give SB in Scenario 2 was higher across all practice locations, the difference in proportions between practice locations persisted ($p = 0.001$). The only other respondent characteristic significantly associated with differences in SB use in Scenario 1 was the number of years in practice, with more years in practice associated with lower likelihood to give SB ($p = 0.032$). However, these findings did not persist for Scenario 2. Differences in SB use for Scenario 2 were found based on residency training ($p = 0.001$) and type of advanced life support certification ($p = 0.015$).

Proposed clinical trial

When asked how important it was to perform a clinical trial to guide intra-arrest SB use, 188 (84 %) respondents felt it was at least of average importance (Fig. 2). When asked how comfortable they would feel about enrolling their patients in a randomized controlled trial comparing intra-arrest SB to placebo, 140 (63 %) said they would be "somewhat" or "very comfortable." For the 37 (17 %) respondents who said they would *not* be comfortable enrolling patients in the proposed trial, open-ended responses included concerns for either withholding or administering SB, especially in circumstances for which they believed SB was indicated or contraindicated.

> "Having a patient randomized to placebo when they have a pre-arrest condition for which bicarbonate would be indicated." R98

Several respondents also felt they needed more information on either study design or the existing data before enrolling patients in the trial:

> "I might be reassured by a synopsis of existing literature on bicarb – I haven't done a deep dive on this in a while – if it shows genuine knowledge gap or lack of efficacy." R221

Others questioned the timing of the intervention in the proposed trial, suggesting administration later into the arrest:

> "Would rather be later in the cardiac arrest timeline not after first dose of epi[nephrine], but later such as after second dose." R240

Discussion

In this cross-sectional electronic survey of pediatric and adult EM, ICU and anesthesia physicians, roughly one quarter of clinicians reported that they would "probably" or "definitely" give SB at 10 min of CPR in an undifferentiated asystolic arrest, which increased to approximately one half at 20 min of CPR. This proportion is similar to the observed rate of SB administered in pediatric and adult IHCA in the US. [27,28]. The indications and thresholds to use SB, reasons for use or avoidance of SB, and beliefs surrounding the physiologic mechanisms of SB during cardiac arrest varied amongst clinicians. We additionally found significant practice variations based on respondent characteristics, including primary practice location, years in practice, residency training and type of advanced life support certification.

Some of the most commonly cited indications for SB use in our survey were in line with AHA guidelines, such as hyperkalemia and tricyclic antidepressant overdose[25,26]. However, most respondents also cited duration of CPR and degree of acidosis as driving factors, despite *not* being supported by AHA guidelines. These results are consistent with previous survey work by Parker et al. with pediatric ICU and ED physicians[34]. Our study expands on these findings by exploring reasons for intra-arrest SB use, including SB as a "last ditch effort" in a prolonged arrest, and the belief SB could provide physiological benefits by reversing acidosis. Along these lines, one theme that emerged was that acidosis is one of the "H's and T's" of reversible causes of cardiac arrest as delineated by AHA guidelines. Yet, somewhat paradoxically, the guidelines do not specify acidosis as an indication for intra-arrest SB [25,26]. Additional indications reported in our study which fell outside of AHA cardiac arrest guidelines included other specific diagnoses and arrest rhythms.

In a broader context, these data highlight practices and beliefs that seem to contradict AHA guidelines. Participants in this study appeared to acknowledge this discrepancy, as only a small minority of the cohort indicated that they thought their use of intra-arrest SB was consistent with AHA guidelines. We hypothesize that this divergence from AHA recommendations ultimately stems from lack of definitive evidence supporting or refuting the use of SB during cardiac arrest in humans. Only two large randomized controlled trials conducted in the 1990's compared intra-arrest SB versus placebo. Though both trials failed to detect differences in outcomes in the overall cohort [19,24], it is difficult to extrapolate these results to modern day IHCA given the inherent

Table 2
Practice characteristics surrounding intra-arrest sodium bicarbonate use amongst survey respondents.

Practice Characteristic	N = 224
Circumstances for Intra-Arrest Sodium Bicarbonate Use	
Hyperkalemia	175 (78)
Pre-existing metabolic acidosis	170 (76)
Median pH threshold (IQR); n = 145	7.1 (7, 7.2)
Median bicarbonate level threshold (IQR); n = 23	15 (12, 18)
Median base excess threshold (IQR); n = 2	−7.5 (−10, −5)
Prolonged Arrest with known or presumed metabolic acidosis	143 (64)
Median time, minutes (IQR)	15 (10, 20)
Pulmonary hypertensive crisis prior to arrest	65 (29)
Shock/hypotension preceding arrest	52 (23)
TCA overdose	159 (71)
Other	9 (4)
None	6 (3)
Reasons for Using Intra-Arrest Sodium Bicarbonate	N = 207
Current literature is insufficient to show harm from intra-arrest sodium bicarbonate	75 (36)
Good outcomes associated with sodium bicarbonate use	24 (12)
“Last ditch effort” in a prolonged arrest when other intra-arrest interventions have failed	156 (75)
Low risk intervention	88 (43)
Part of training	44 (21)
Physiologic benefits to treating intra-arrest acidosis such as optimizing efficacy of pressors/ myocardial function or reversal of the underlying cause of arrest	131 (63)
Use of intra-arrest sodium bicarbonate is consistent with ACLS/PALS guidelines	30 (14)
Other	8 (4)
None	10 (5)
Reasons to Avoid Intra-Arrest Sodium Bicarbonate Use	N = 17
Bad outcomes associated with sodium bicarbonate use	0 (0)
Current literature shows an association with sodium bicarbonate use and poor outcomes	6 (35)
May worsen intra-cellular acidosis in vital organs	6 (35)
Part of training	3 (18)
Avoidance of intra-arrest sodium bicarbonate is consistent with ACLS/PALS guidelines	8 (47)
Other	1 (6)
None	2 (12)

Response options have been paraphrased for brevity.
Abbreviations: IQR, interquartile range; TCA, tricyclic antidepressant; ACLS, advanced cardiovascular life support; PALS, pediatric advanced life support.

differences between IHCA and OHCA, including baseline characteristics, comorbidities, arrest etiologies, event characteristics, time-to-treatment, access to advanced therapies and outcomes[35,36]. A more recent adult OHCA trial was not powered to clinical outcomes[37].

Observational studies in both pediatric and adult cardiac arrest have shown associations with SB and worse outcomes [15–18]; however, these studies are limited by the lack of timing of SB administration, leading to serious risk for resuscitation time bias[38]. Our findings of increased likelihood of SB use during prolonged arrest and use as a “last ditch effort” indicate this effect may be especially profound for SB. Given these significant limitations, it is possible that the existing evidence is not strong enough to dispel historical practices and beliefs about SB use during cardiac arrest[39]. This theory is further supported by our finding that the majority of respondents felt that a randomized clinical trial surrounding intra-arrest SB was at least of average importance and would feel comfortable having their patients enrolled in such research.

Additionally, we noted differences in the likelihood of giving SB in

Table 3
Proportion of respondents who would “probably” or “definitely” administer sodium bicarbonate in Scenario 1 (10-minute asystolic arrest) and Scenario 2 (20-minute asystolic arrest) by respondent characteristics.

	Number of respondents per row (n)	Would Give SB in Scenario 1 n (%)	p-value	Would Give SB in Scenario 2 n (%)	p-value
Residency Training			0.119		0.001
Anesthesia	74	19 (26)		40 (54)	
Emergency Medicine	21	2 (10)		4 (19)	
Internal Medicine	21	9 (43)		17 (81)	
Pediatrics	83	20 (24)		36 (43)	
Multiple[a]	21	3 (14)		11 (52)	
Fellowship Training			0.13		0.093
Adult Pulmonary/ Critical Care Medicine	21	9 (43)		17 (81)	
Anesthesia Critical Care Medicine	14	4 (29)		7 (50)	
Pediatric Anesthesia	44	9 (20)		20 (45)	
Pediatric Critical Care Medicine	40	12 (30)		18 (45)	
Pediatric Emergency Medicine	36	3 (8)		13 (36)	
Other[b]	20	4 (20)		9 (45)	
None	26	7 (27)		14 (54)	
Multiple	23	6 (26)		12 (52)	
Patient Population			0.142		0.094
Majority Adult (>75 %)	81	24 (30)		46 (57)	
Majority Pediatric (>75 %)	142	29 (20)		63 (44)	
Practice Location			0.025		0.001
Adult Emergency Department	20	2 (10)		4 (20)	
Adult Operating Room	25	8 (32)		18 (72)	
Adult ICU	24	9 (38)		18 (75)	
Pediatric Emergency Department	38	3 (8)		13 (34)	
Pediatric Operating Room	44	9 (20)		21 (48)	
Pediatric ICU	56	18 (32)		26 (46)	
Multiple	17	5 (29)		10 (59)	
Years in Practice[c]			0.032 *C-A Trend test		0.93 *C-A Trend test
0 to < 3 years	46	16 (35)		19 (41)	
3 to < 5 years	19	7 (37)		10 (53)	
5 to < 10 years	47	10 (21)		27 (57)	
10 to < 15 years	25	4 (16)		13 (52)	
15 to < 20 years	33	7 (21)		17 (52)	
20 or more years	54	10 (19)		24 (44)	
Certifications			0.21		0.012
ACLS	58	18 (31)	58	38 (66)	
PALS	42	12 (29)	42	21 (50)	
Both	120	24 (20)	120	50 (42)	
Average number of code			0.587		0.698

(*continued on next page*)

Table 3 (*continued*)

	Number of respondents per row (n)	Would Give SB in Scenario 1 n (%)	p-value	Would Give SB in Scenario 2 n (%)	p-value
events in a 12-month period[c]					
0	11	0 (0)		5 (45)	
1–2	73	18 (25)		30 (41)	
3–5	64	17 (27)		36 (56)	
6–10	34	9 (27)		20 (59)	
11–15	26	7 (27)		14 (54)	
16 or more	16	3 (19)		5 (31)	

Categories with < 5 were grouped with other categories or excluded from analysis. Abbreviations: ICU, intensive care unit; ACLS, advanced cardiovascular life support.

[a] Includes Med/Peds.

[b] Includes Emergency Medicine/Critical Care Medicine and Adult Cardiology.

[c] Cochrane-Armitage test for trend.

our two cardiac arrest scenarios based on clinician characteristics. Differences based on practice location, residency training and type of advanced life support certification may be explained by a combination of training, departmental culture and/or the frequency or etiology of cardiac arrest occurring in each of these settings. In the open-ended responses, some respondents identified team influence or "peer pressure" as a reason they would administer intra-arrest SB. Peer pressure and "conformity to peers" are prevalent influences in medical education.[40]. These norms can be considered a hidden curriculum which are organizational and cultural influences that often inform clinical practice.[41].

We also found that more years in practice was associated with a lower likelihood of giving SB at 10 min of CPR, but not at 20 min. This trend may reflect that more experienced clinicians prioritize other measures early in the arrest while less experienced clinicians may try these additional measures earlier. Alternatively, this may reflect a generational change in training or culture surrounding intra-arrest SB. However, this explanation seems less likely given that AHA guidelines have only strengthened the language of their recommendations against routine use of SB over time[25,26,42–44].

Our findings should be interpreted in the context of some limitations. First, we could not control nor assess for responder bias. Additionally, social desirability bias may have influenced some responses surrounding practices inconsistent with AHA guidelines. Finally, we only sampled physicians from two local institutions, and therefore the culture and training surrounding intra-arrest SB may significantly differ in other locations.

Conclusions

Adult and pediatric EM, ICU and anesthesia physicians reported significant practice variations surrounding cardiac arrest management with SB. Some of the most commonly reported indications for using intra-arrest SB are not supported by current AHA guidelines, including acidosis and duration of arrest. Stronger evidence supporting or refuting use of intra-arrest SB is likely needed to achieve more uniform practice in these groups.

CRediT authorship contribution statement

Catherine E. Ross: Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Jill L. Sorcher:** Writing – review & editing, Visualization, Formal analysis. **Ryan Gardner:** Writing – review & editing, Investigation. **Ameeka Pannu:** Writing – review & editing, Investigation. **Monica E. Kleinman:** Writing – review & editing, Supervision, Conceptualization. **Michael W. Donnino:** Writing – review & editing, Supervision, Conceptualization. **Amy M. Sullivan:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Margaret M. Hayes:** Writing – review & editing, Supervision, Methodology, Conceptualization.

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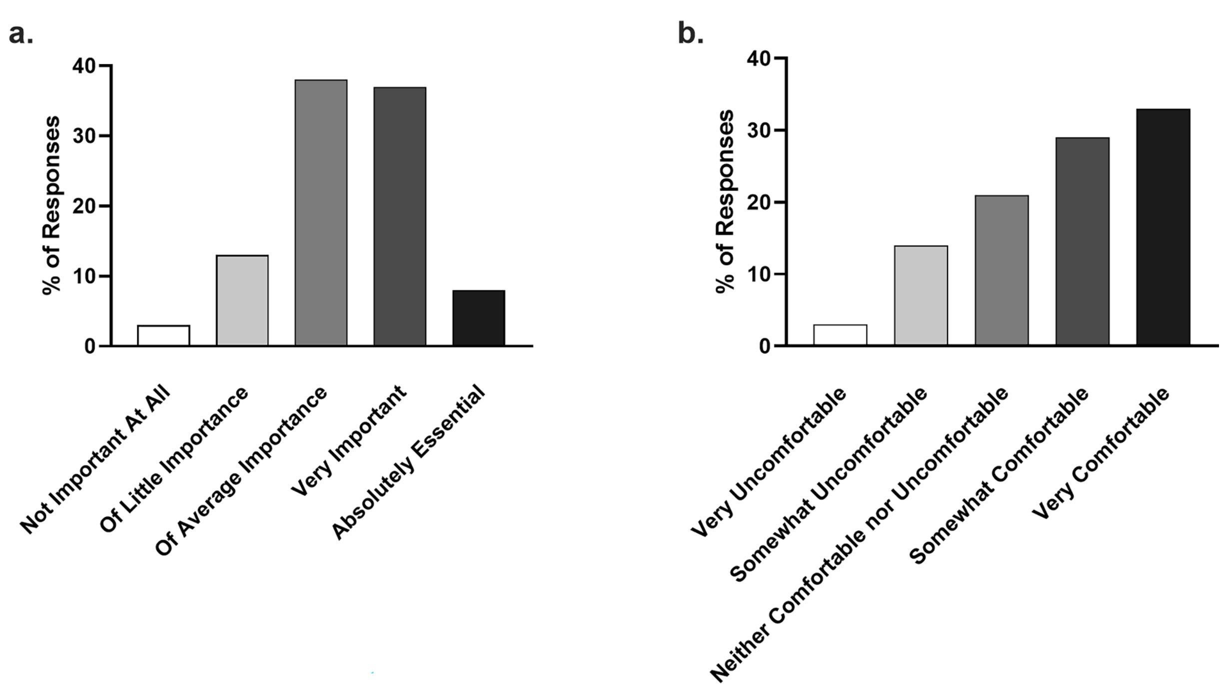

Fig. 2. Likert-type responses for importance (a) and comfort (b) with enrolling in a clinical trial surrounding intra-arrest SB.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2024.100830.

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