Reports of Investigation

Perioperative resuscitation knowledge base

Lorne David Porayko MD FRCPC,
Ronald Butler MD FRCPC

Purpose: To assess the knowledge base of Canadian anesthesiologists regarding the management of perioperative cardiac arrest.

Methods: A random sample of 200 Canadian Anesthesia Society members were mailed a survey composed of 10 clinical vignettes, each involving a special perioperative resuscitation situation, with six multiple choice options for optimum management. Fourteen possible "lethal errors" (options which are unequivocally harmful to the patient) were identified among the possible choices. Each question had a single correct answer and contributed a single point towards a possible maximum of ten. An arbitrary passing score of 70%, similar to the American Heart Association (AHA) standard for Advanced Cardiac Life Support course (ACLS), was selected. Respondents were asked demographic information including: time since completing residency, time since last ACLS course, provision of cardiac anesthesia and attitude towards utility of AHA protocols in anesthesia practice.

Results: A total of 124 surveys were returned. The median score was five with a range of scores from zero to nine. Fifty-eight (56.3%) participants chose at least one "lethal error". Only 17 respondents (13.7%) attained the minimum score of 70% and avoided a "lethal error". Respondents who practiced cardiac anesthesia tended to achieve higher scores ($P < 0.05$) than generalists. All but one participant indicated that a Continuing Medical Education resource covering this material would be useful.

Conclusions: This survey demonstrates a knowledge deficit concerning special perioperative resuscitation situations. Development of further appropriate research and educational material in this area is justified.

Objectif : Évaluer la base des connaissances des anesthésiologistes canadiens sur la conduite à tenir en cas d'arrêt cardiaque périopératoire.

Méthode : Un formulaire d'enquête a été posté à 200 membres de la Société canadienne d'anesthésie choisis au hasard. L'exemplaire était composé de 10 vignettes, chacune représentant une situation spéciale de réanimation périopératoire accompagnée de six propositions d'intervention optimale. Quatorze «erreurs fatales» (choix qui sont incontestablement dangereux pour le patient) ont été placées parmi les choix possibles. Chaque question n'avait qu'une seule bonne réponse et valait un seul point, pour un maximum de dix. La note de passage arbitraire de 70 %, selon les standards de l'American Heart Association (AHA) pour le cours de technique spécialisée de réanimation cardio-respiratoire (Advanced Cardiac Life Support, ACLS), a été choisie. Les répondants ont dû fournir des renseignements démographiques comprenant : la date de la fin de la résidence, la date du dernier cours d'ACLS, l'expérience en anesthésie cardiaque et l'opinion sur l'utilité des protocoles AHA dans la pratique de l'anesthésie.

Résultats : On a renvoyé 124 formulaires. Le score moyen était de cinq, les limites allant de zéro à neuf. Cinquante-huit (56,3 %) participants ont fait le choix d'au moins une «erreur fatale». Dix-sept répondants seulement (13,7 %) ont atteint le seuil de 70 % et évité une «erreur fatale». Les répondants qui pratiquent l'anesthésie cardiaque avaient en général de meilleurs résultats ($P < 0,05$) que les généralistes. Tous les participants, sauf un, ont dit que des ressources de formation médicale continue seraient utiles en ce domaine.

Conclusion : Cette enquête démontre un manque de connaissances des situations spéciales de réanimation périopératoire. La réalisation de recherches complémentaires appropriées et de matériel d'éducation semble donc justifiée.

From the Department of Anesthesiology, Program in Critical Care, London Health Sciences Centre, 339 Windermere Road, London, Ontario N6A 5A5 Canada.

Address correspondence to: Ronald Butler MD, Phone: 519-663-3363; Fax: 519-663-3079; E-mail: rbutler1@julian.uwo.ca

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IN the most recent (1992) Advanced Cardiac Life Support (ACLS) guidelines provided by the American Heart Association (AHA)¹ the subcommittee recognized that physicians outside the emergency room and coronary care unit encountered many complex and unique mechanisms for arrest. The "Special Resuscitation Situations" chapter originally outlined evidence based resuscitation approaches for such situations as stroke, electrical shock, hypothermia, near-drowning, traumatic cardiac arrest, the poisoned patient and arrest in the parturient. In 1997, the International Liaison Committee on Resuscitation (ILCOR) Advisory Statement issued by the AHA expanded the existing protocols to include both basic life support and advanced life support modifications for pediatric arrest, electrolyte abnormalities, hyperthermia, renal failure, status asthmaticus, anaphylaxis, traumatic arrest, and the geriatric patient.² There is one page in this document that discusses the general approach to management of hemodynamic collapse during anesthesia.

To our knowledge, there is no text or structured course available to anesthesia practitioners that focuses on perioperative resuscitation situations. In order to determine if a knowledge deficit exists among anesthesia practitioners concerning the management principles in these complex situations, we set out to develop a survey instrument that would measure the Canadian clinical anesthesiologist's practical knowledge regarding the management of special resuscitation situations during anesthesia and surgery. We were also interested in the relationship between participant's score and both the time lapsed since his/her residency training and the time since last ACLS course, the influence of the practice of cardiac anesthesia and the perceived utility of current AHA guidelines in anesthesia practice.

Methods

The questionnaire (Appendix) was composed of 10 clinical vignettes, each involving a special intraoperative resuscitation situation. Following each scenario, participants were asked to select the best management option from six alternatives in a conventional multiple choice format. The sixth answer option for each case was "I don't know". The cases chosen for the survey represented rare but treatable causes of cardiac arrest that were obtained by reviewing cases of perioperative cardiac arrests at a large teaching hospital. Each vignette was derived from a patient's chart and correlated with at least one other similar case report in the literature. Correct answers were determined from existing ACLS guidelines and references in the resus-

citation literature. Each question had a single correct answer and contributed a single point towards the total score if chosen by the respondent. The maximum score was ten; the minimum score was zero. The AHA ACLS standard for a passing score of 70% or greater was applied to our survey. Fourteen possible "lethal errors", (responses which would be unequivocally harmful to the patient either as a direct result of the action or by misdirecting therapeutic efforts), were identified among the possible choices. Some clinical vignettes had more than one potential lethal error while others had none. The sixth answer option ("I don't know") was not considered a lethal error. The questionnaire was then presented to several members of both the Department of Anesthesia and the Program in Critical Care at the University of Western Ontario for consensus regarding clarity and validity of each question.

Demographic information concerning the length of time since completing residency, time since last ACLS course (if taken at all), current involvement in cardiac anesthesia and attitude towards the utility of AHA protocols in anesthetic practice was inquired of participants. Respondents were also asked if they felt a continuing medical education resource covering the material tested on the survey would be useful.

The survey was pretested using a convenience sample of 32 anesthesiologists at London Health Sciences Centre on October 12, 1997. In order to estimate the required sample size, a normal distribution of total scores was assumed and the sample size was calculated to estimate the mean score $\pm$ five percent using the standard deviation from the pretesting. A total of 100 responses were required. Assuming a 50% response rate a total mailing of 200 questionnaires was necessary. Two hundred Canadian Anesthesia Society members were randomly chosen from the membership directory and mailed a questionnaire. Resident members and members not in active practice were excluded. Anesthesiologists from the Department of Anesthesia at the University of Western Ontario were also excluded because of their exposure to the questionnaire during the pretesting. After a six week period, there was a second mailing to the non-responders. Participants were assured of anonymity.

Returned surveys were marked and confirmed by one investigator (LDP). Scores and all participant responses were recorded along with demographic data in a Microsoft Excel 97 spreadsheet. Statistical analysis was done using SPSS 8.0 (Chicago IL). The total score is reported both as mean $\pm$ standard deviation (SD) and median with range. Individual questions or responses are reported as frequency correct.

Relationships between total score and demographic factors were explored using the Kruskal-Wallis test, a non-parametric analysis of variance. Associations significant at the $P < 0.05$ level were further explored with sequential group comparisons using the Mann-Whitney test with a downward adjustment of the alpha level ($\alpha = 0.05/\text{number of comparisons}$) to avoid spurious associations from multiple testing. Only associations that remained significant on post-hoc testing are reported as significant.

Results

The first mailing produced 103 responses. The follow-up mailing prompted 21 more returned surveys for a total of 124 responses. All 124 responses were included in the analysis. The demographic data are presented in Table I. Thirteen (10%) participants did not provide demographic information. Overall, the mean score was 5.1 (SD 1.74) and the median was 5 with a range of scores from zero to nine (Figure 1). The mean score of those respondents who provided demographic data was 5.2 (SD 1.64) and those who did not had a mean score of 4.31 (SD 2.32). The median score for both groups was 5. The percentage correct for each question is listed in Table II. These scores ranged from a low of 27% to a high of 78%.

Fifty-eight (56.3%) participants chose at least one "lethal error". Twenty-five (20.2%) respondents attained the 70% minimum score but only 17 (13.7%) attained the minimum score of 70% and avoided any "lethal error". A total of 132 lethal errors were chosen as responses. The lethal errors and the frequency that they were chosen are shown in Table III.

There was no relationship between score and years post residency or time since last ACLS course. There was a trend toward a higher score of those respondents who did not find the ACLS protocols useful to anesthetic practice compared with those who were not familiar with the protocols but this did not reach statistical significance. Those respondents who practice cardiac anesthesia achieved higher scores than those who did not practice cardiac anesthesia ($P < 0.05$). All but one participant indicated that a Continuing Medical Education resource covering this material would be useful.

Discussion

Intraoperative cardiac arrest occurs in approximately 1 in 1600 adults undergoing anesthesia in North American centres.³ In one study, successful intraoperative resuscitation (return of spontaneous circulation) was established in approximately 60% of patients, with 38% surviving discharge from hospital.³ These figures

TABLE I Respondent Demographics

	Number
1. Years since Qualifying from Residency	
< 5 yr	9
5 – 10 yr	40
> 10 yr	62
No response	13
2. Years since Completion of ACLS course	
< 1 yr	14
1 – 5 yr	21
6 – 10 yr	31
> 10 yr	24
Never	21
No response	13
3. Conduct of Cardiac Anesthesia	
No	91
Yes	20
No response	13
4. Usefulness of ACLS Protocols in Anesthetic Practice	
Useful	60
Not useful	21
Not familiar with protocols	30
No response	13

TABLE II Breakdown of Scoring by Question

Question	% Correct
1. Succinylcholine induced hyperkalemic arrest in a burn patient	71%
2. Ventricular fibrillation in patient with implantable defibrillator	30%
3. Rapid irregular wide complex rhythm in patient with Wolf-Parkinson-White syndrome undergoing cataract extraction...	41%
4. Bupivacaine induced cardiac arrest in parturient	39%
5. Pulseless electrical activity in a patient with chronic obstructive lung disease secondary to auto-PEEP	48%
6. Torsade des Pointes in patient with congenital prolonged QT interval	63%
7. Severe bradycardia and hypotension secondary to beta-blocker overdose	27%
8. Malignant Hyperthermia with rapid SVT and hypertension...	50%
9. Complete heart block in patient with LBBB induced by pulmonary artery catheter	78%
10. Bradycardia and hypotension in trauma victim with severe hypothermia.....	73%

markedly exceed the highest survival rates reported for both in-hospital and out-of-hospital arrests (24% and 22% for witnessed arrests, respectively).³ Approximately half of the arrests during anesthesia are deemed to have a primary cardiac etiology, whereas outside the operating room setting this cause for hemodynamic collapse appears to be much more common.⁴

TABLE III Potential Lethal Errors Chosen by Respondents

<i>Error</i>	<i>Frequency Chosen</i>
1. Wolf Parkinson White (WPW) patient with wide complex tachycardia treated with digoxin.	5
2. WPW patient with wide complex tachycardia treated with verapamil.	25
3. WPW patient with wide complex tachycardia treated with diltiazem.	12
4. Pulseless Electrical Activity (PEA) with a rhythm of sinus tachycardia treated with electrical cardioversion.	16
5. PEA with a rhythm of sinus tachycardia treated with procainamide.	0
6. Torsade des Pointes treated with procainamide boluses.	10
7. Torsade des Pointes treated with amiodarone.	4
8. Torsade des Pointes treated with procainamide infusion.	0
9. Idioventricular rhythm, (rate 30/ min), treated with bretylium.	0
10. Idioventricular rhythm, (rate 30/ min), treated with amrinone.	2
11. Malignant Hyperthermia (MH) crisis with supraventricular tachycardia (SVT) and hypertension treated with defibrillation	24
12. MH crisis with SVT and hypertension treated with verapamil.	22
13. Pulmonary Artery Catheter (PAC) induced complete heart block with no ventricular escape treated with lidocaine	0
14. PAC induced complete heart block with no ventricular escape treated with isoproterenol	12

The relatively high successful resuscitation rates suggest that treatable etiologies of arrest are common during anesthesia and are usually rapidly detected and treated by experienced and skilled clinicians. An average practitioner might encounter 10-15 such events during the span of a career;⁵ therefore, few obtain wide personal experience during their training and beyond to establish and maintain knowledge in this specialized area.

No previous surveys of theoretical knowledge applied to resuscitation by anesthesiologists exist in the literature. Simulation-based Anesthesia Crisis Resource Management Training has been utilized by at least two major institutions and initial surveys have established that the majority of clinicians have found their own cognitive and psychomotor skills initially inadequate to manage rarely encountered intraoperative complications.^{6,7} A recent study of the application of the ACLS guidelines by Canadian anesthesia practi-

tioners, using a cardiac arrest simulation showed that 61 percent of participants committed major deviations from the ACLS protocols when managing a simulated ventricular fibrillation arrest. Major deviations from the protocols included: failure to discontinue the anesthetic, failure to administer epinephrine or to defibrillate.⁸ It is imperative that anesthesiologists have the knowledge to manage these complications because it is not possible to reliably predict their occurrence and they are often treatable if they are recognized rapidly and managed appropriately.

This survey was developed to test the cognitive knowledge of Canadian anesthesiologists regarding special perioperative resuscitation situations. The survey was based on cases from a chart review performed at a large teaching institution. Nevertheless many of the scenarios represent patients and procedures that could be encountered in a non-teaching hospital.

The mean score of the respondents was lower than expected. Assuming that the AHA ACLS objective standard is reasonable, we would expect that the majority of participants would score above an arbitrary passing score of 70%. The survey was designed to be short in order to reduce the time required to complete the survey and increase the response rate. Consequently each question has more weight in the total score. The difficulty and complexity of the questions is nearly impossible to quantify and there is always a certain amount of controversy concerning optimal resuscitation approaches. It is possible that the best answer may have appeared ambiguous and the lower mean score reflects confusion with the question rather than lack of knowledge. In order to avoid this problem we have emphasized the lethal error rate. These are errors that either directly harm the patient or misdirect therapeutic efforts with useless therapies. We also introduced the potential response "I don't know" in each question in order to allow the participant an opportunity to recognize his/her knowledge deficit concerning the specific resuscitation principle. This option could also be chosen if the participant felt that a question was difficult to interpret. We did not identify the "I don't know" response as a lethal error because it did not exclude seeking assistance for the cardiac arrest management.

The high incidence of selection of at least one lethal error by respondents (56.3%) is notable, and many respondents made more than one lethal error. The most common lethal errors were the treatment of a WPW patient with wide complex tachycardia with a calcium channel blocker (37/124) and treatment of an MH crisis complicated by an SVT with stable vital signs by administering *iv* verapamil (24/124).

Although one might expect that most errors would be associated with knowledge that has been recently elucidated and possibly not widely disseminated, both of these therapeutic misadventures have been well documented in the literature for over 15 yr.^{9,10}

The response rate to the survey was above 50%. However, a large non-responder bias may influence these results. We have considered that returned surveys might represent attempts from participants with more confidence in their knowledge and experience regarding this topic. This may be reflected in the proportion and the results of respondents who practice cardiac anesthesia (20 of 124). This proportion seems high given the limited number of sites within the country that have cardiac anesthesia practices. If this were the case, then the bias that would be introduced would result in overestimating the score and underestimating the lethal error rate. Conversely if the entire non-responding population represented participants that would score one hundred percent and select no lethal errors on the survey then the lethal error commission rate would still be considerable (exceeding 25%).

The secondary analysis of associations between scores and the demographic variables was done as a hypothesis generating exercise and we used a conservative approach of using a non-parametric ANOVA procedure and applying a downward adjustment to the alpha level for post-hoc testing to avoid spurious associations caused by multiple testing. The tendency for higher scores in the cardiac anesthesiologist group ($P < 0.05$) might be explained by the association with the practice of cardiac anesthesia and teaching centre hospitals (which also provides convenient and frequent access to CME resources). Other possible reasons may be more critical care training during cardiac anesthesia fellowships and possibly a greater experience and knowledge concerning resuscitation drug pharmacology. It is interesting that there was a trend to a higher score among those respondents who felt that the AHA ACLS protocols were not useful for anesthetic practice when compared with those respondents who were not familiar with the protocols. It was impressive that the overwhelming majority of the respondents felt that more continuing medical education opportunities in this area would be useful.

Conclusions

This survey of Canadian anesthesia practitioner's knowledge database concerning special intraoperative resuscitation situations demonstrated lower mean scores and a higher lethal error commission rate than expected. This finding suggests that further research and educational resources (such as Anesthesia Crisis Resource

Management and specialized anesthesia resuscitation courses) should be directed to this knowledge deficit.

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Appendix: Perioperative Resuscitation Survey

Answer code (printed to the right of each response)

- 1 correct answer
- 2 incorrect answer, less preferable alternative
- 3 incorrect maneuver
- 4 definitely harmful treatment, lethal error

1. A forty year old male, 6 mo out from a 60% body surface area burn returns to OR for yet another skin grafting procedure. Things go well until the end of the case when on extubation, the patient demonstrates severe inspiratory stridor, and desaturates to 75%. Efforts to alleviate laryngospasm with positive pressure ventilation and PEEP fail to move air and improve oxygenation. In a moment of weakness 40 mg of succinylcholine is delivered *iv*. Ventilation is now easy, however, t waves on ECG rapidly peak, followed by a rapid wide complex tachycardia, then asystole....

The initial pharmacological treatment that will most rapidly treat the cause of this patient's cardiac arrest is:

a) epinephrine	2
b) bicarbonate	2
c) bretylium	3
d) amiodarone	3
e) calcium gluconate	1
f) I don't know	

2. A 65 yr old man with poor LV function, a history of multiple previous episodes of ventricular tachycardia associated with cardiovascular collapse, and an AICD (automated internal cardioverter/defibrillator device) in situ, presents for elective inguinal hernia repair. He demands a GA and you provide fentanyl/sTP/rocuronium induction after arterial line placement, preoxygenation and establishment of "Crash Cart" in the OR. After an easy intubation, you note a wildly disorganized ECG trace, no recordable blood pressure, EtCO₂, or palpable pulse. Intermittent square waves on the ECG appear synchronously with pectoralis muscle contractions which you are sure represents the AICD's repeated internal shocks.

After rapid assessment of ABC's, your FIRST action would be:

a) hyperventilate with 100% O ₂	2
b) 1 mg epinephrine <i>iv</i> to support the circulation	2
c) lidocaine 1-1.5 mg·kg ⁻¹ <i>iv</i>	3
d) place magnet over AICD to inactivate it	3
e) DC countershock with paddles anteroposterior	1
f) I don't know	

3. A patient with Wolf-Parkinson-White syndrome undergoes GA for cataract extraction. Which drug would be most appropriate for

treating a wide complex irregularly irregular rhythm, with a ventricular response of 250 contractions/min, and a BP of 90/40?

a) digoxin	4
b) lidocaine	3
c) diltiazem	4
d) procainamide	1
e) verapamil	4
f) I don't know	

4. You have just executed a technically flawless obstetric lumbar epidural in the labour and delivery suite. Test dose of 3 ml of 1.5% lidocaine 1:200 000 epinephrine is negative for block or CNS symptoms; however, hemodynamic findings are equivocal as usual. 12 ml of .25% bupivacaine is administered via the epidural catheter in slow increments. Approximately 45 sec later you note the patient's brief generalized seizure, followed by profound fetal bradycardia, maternal apnea, and a pulseless, wide complex tachycardia approximately 160/min on the crash monitor.

After initial resuscitation (airway control and ventilation, 3 stacked DC transthoracic shocks, fluid bolus, left uterine displacement) fails, the management priority is:

a) bretylium 5 mg·kg ⁻¹ <i>iv</i> because it has been shown to be most effective in LA overdose	2
b) high dose epinephrine	2
c) continue shocks at maximum energy	3
d) expedient delivery	1
e) overdrive pacing ASAP	3
f) I don't know	

5. A 45 kg, 55 yr old man with stable COPD (FEV₁=.81) is scheduled for urgent laparotomy because of presumed sigmoid volvulus. After initiation of GA and intubation, EtCO₂ = 75, and in efforts to achieve a somewhat physiological value the ventilator is set to: Vt = 980 ml, f = 18, PEEP = 5. EtCO₂ is now 47 but systolic blood pressure drops precipitously to 58 systolic. 500 ml of crystalloid is administered, and soon afterward the patient is pulseless with sinus tachycardia (approximately 180/min). Trachea is midline, breath sounds are equal. Surgeons are performing CPR.

Initial management:

a) repeat fluid bolus	2

- b) 30-60 sec of apnea 1
- c) epinephrine 1 mg *iv* 2
- d) synchronized cardioversion at 100 joules 4
- e) procainamide 17 mg·kg⁻¹ at 30 mg·min⁻¹ 4
- f) I don't know

6. A colleague summons your aid by pushing the "code" buzzer late one evening. His patient is a currently moderately hypotensive (systolic blood pressure=80) 33 yr old male undergoing GA for appendectomy. He has known Romano-Ward syndrome (a long QT syndrome). A bizarre, polymorphic, wide complex rhythm is evident on the monitor, for which the anesthesiologist has been delivering procainamide 100 mg *iv* q 5 min without success after 400 mg total dose.

Practical and effective therapy you would recommend would be:

- a) continue giving procainamide up to maximum dose approximately 1000mg 4
- b) amiodarone 5 mg·kg⁻¹ over 1 hr 4
- c) lidocaine 100 mg *iv* 3
- d) procainamide infusion 17 mg·kg⁻¹ at a rate of 25 mg·min⁻¹ 4
- e) magnesium sulfate 2 gm *iv* over 5 min 1
- f) I don't know

7. During a craniotomy for meningioma in an otherwise healthy 56 yr old male, intra-operative hypertension is treated expediently by the anesthesia resident with labetalol 100 mg as a bolus over one minute. When you enter the room, the patient's ECG shows an idioventricular rhythm of 30 complexes/minute, and the BP is 40 systolic.

The most effective pharmacologic treatment of this situation is:

- a) calcium gluconate 1 gm *iv* q 10 min 2
- b) glucagon 2.5 mg *iv* 1
- c) epinephrine 10 µg *iv* 2
- d) bretylium 5 mg·kg⁻¹ *iv* 4
- e) amrinone .5 mg·kg⁻¹ *iv* 4
- f) I don't know

8. You are assisting a colleague in management of a fulminant MH crisis. While undergoing usual resuscitation measures and dantrolene loading the patient demonstrates atrial fibrillation with a ventricular response of 210 bpm. Her BP is 190 and urine output is reasonable.

Initial management:

- a) verapamil 2.5 mg *iv* 4
- b) esmolol 500 µg·kg⁻¹ *iv* 1
- c) digoxin .25 mg *iv* 2
- d) defibrillation at 200 joules 4
- e) sodium bicarbonate 1 meq·kg⁻¹ *iv* 2
- f) I don't know

9. An 80 yr old man with moderate LV dysfunction, scheduled for elective AAA resection and grafting and is noted to have a LBBB and first degree heart block on his preop ECG. He denies any cardiac symptoms. A Swan-Ganz catheter is passed effortlessly after a largely unremarkable GA induction until BP drops to zero, and only p waves are noted on the ECG monitor....

Once CPR is under way, the most effective intervention would be:

- a) isoproterenol 2-10 µg·min⁻¹ infusion 4
- b) lidocaine 1.5 mg·kg⁻¹ *iv* 4
- c) atropine .5 mg *iv* 2
- d) glycopyrrolate .3 mg *iv* 2
- e) transthoracic pacing at 300 mA 1
- f) I don't know

10. A 44 yr old alcoholic multiply traumatized male is transferred (intubated) directly to OR after grossly positive DPL. HR is 44 (sinus bradycardia) BP is 75, and the patient is polyuric. His core temperature is 29°C. On transfer to the OR table his monitor shows ventricular fibrillation and he is pulseless. "Crash Cart" is present in OR.

Practical initial management:

- a) 3 DC counter shocks at 200, 300 and 360 J then actively rewarm 1
- b) epinephrine 1 mg *iv* 2
- c) initiate femoral/femoral CPB (cardiopulmonary bypass) and rewarm 2
- d) gastric lavage with warm fluids (45°C) then defibrillate 2
- e) precordial thump 2
- f) I don't know