

## Resuscitation after cardiac surgery: results of an international survey

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Received 11 November 2008; accepted 23 February 2009; Available online 14 April 2009

### Abstract

**Objective:** A survey was conducted on CTSNet, the cardiothoracic network website in order to ascertain an international viewpoint on a range of issues in resuscitation after cardiac surgery. **Methods:** From 40 questions, 19 were selected by the EACTS clinical guidelines committee. Respondents were anonymous but their location was determined by their Internet protocol (IP) address. The responses were checked for duplication and completion errors and then the results were presented either as percentages or median and range. **Results:** From 387 responses, 349 were suitable for inclusion from 53 countries. The median size of unit of respondents performed 560 cases per year. The incidence of cardiac arrest reported was 1.8%, emergency re-sternotomy after arrest 0.5% and emergency re-institution of bypass 0.2%. Only 32% of respondents follow current guidelines on resuscitation in their unit and an additional 25% of respondents have never read these guidelines. Respondents indicated that they would perform three attempts at defibrillation for ventricular fibrillation without intervening external cardiac massage and for all arrests perform emergency re-sternotomy within 5 min if within 24 h of the operation. Fifty percent of respondents would give adrenaline immediately, 58% of respondents would be happy for a non-surgeon to perform an emergency re-sternotomy and 76% would allow a surgeon's assistant and 30% an anaesthesiologist to do this. Only 7% regularly practise for arrests, but 80% thought that specific training in this is important. **Conclusion:** This survey supports the EACTS guideline for resuscitation in cardiac arrest after cardiac surgery published in this issue of the journal.

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**Keywords:** Resuscitation; Survey; Thoracic surgery; Cardiac arrest; Cardiac surgery; Emergency re-sternotomy

### 1. Introduction

It has been recognised that several issues in the management of arrest after cardiac surgery are different compared to cardiac arrest in other circumstances. For the first time, The European Resuscitation Council (ERC) issued some guidance in this area in their latest guidelines in 2005 [1]. The Clinical Guidelines committee of the European Association for Cardio-Thoracic Surgery (EACTS) launched a project to create a set of clear and detailed guidelines to apply specifically to resuscitation after cardiac surgery in 2007 and their findings are published in this edition of the EJCTS [2]. This guideline was derived using a multimodal strategy for evidence generation. Where evidence was available in cardiac surgery, a structured literature review was performed and published in the ICVTS [3]. The management of many issues in resuscitation are already

well established and, if applicable, the International Liaison Committee on Resuscitation guidelines [4] were referenced. Practical and organisational issues in resuscitation after cardiac surgery were addressed by testing on manikins with personnel from cardiothoracic surgery and ICU teams during 17 courses teaching resuscitation in patients after cardiac surgery [5–7]. However there are many important issues that face cardiac surgeons in their practice for which there were no published papers to guide the committee. Thus an international survey on CTSNet was commissioned in order to gain the views and opinions of as many cardiac surgeons as possible to guide the committee in their decision-making. The results of this survey are presented here.

### 2. Methods

A survey was created on CTSNet, the Cardiothoracic Surgery Network ([www.ctsnet.org](http://www.ctsnet.org)). Forty questions were initially created for this survey and after consultation with

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Table 1  
The CTSNet survey questions.

Prevalence of cardiac arrest in the intensive care unit	
1	How many cardiac surgical procedures did your unit perform in the past 12 month?
2	How many patients in the past 12 months do you estimate required closed chest compressions for cardiac arrest in your cardiac intensive care following cardiac surgery?
3	How many patients in the past 12 months who suffered a cardiac arrest on your cardiac intensive care unit required emergency re-sternotomy as part of the resuscitation?
4	How many patients in the past 12 months who required an emergency re-sternotomy also required a return onto cardiopulmonary bypass?
5	Of all patients who arrested, what percentage of these do you estimate survived to hospital discharge?
Cardiac arrest with ventricular fibrillation	
6	With regard to patients who go into ventricular fibrillation or pulseless ventricular tachycardia on your cardiac intensive care have you ever experienced successful return to a spontaneous circulation with a precordial thump? (a) I have witnessed one or more successful occasions (b) I have never witnessed this but I have heard of success in cardiac surgical patients (c) I have never witnessed or heard of success but I would have a go if I thought it was appropriate (d) I have never witnessed or heard of success and I think that it is benign but of little use (e) I think that this is a potentially harmful manoeuvre and would not condone its use
7	If a patient goes into ventricular fibrillation or pulseless ventricular tachycardia on your cardiac intensive care after cardiac surgery do you think that they should: (a) Receive immediate external chest compressions followed by defibrillation as soon as available (b) Have defibrillation as soon as possible and only commence external chest compression after 1–3 attempts at defibrillation have failed
8	On your unit if a patient goes into ventricular fibrillation or pulseless ventricular tachycardia what is your preferred sequence of defibrillation attempts? (a) I would perform three attempts at defibrillation in a row, then commence chest compressions for 2 min with a single shock after each 2-min cycle (b) I would perform single attempts at defibrillation with external chest compressions for 1 min between attempts (c) I would perform single attempts at defibrillation with external chest compressions for 2 min between attempts (d) I would perform three attempts at defibrillation in a row, with external chest compressions for 1 min between sequences (e) I would perform three attempts at defibrillation in a row, with external chest compressions for 2 min between sequences
9	For patients in established cardiac arrest when do you think that administration of epinephrine (adrenaline) is warranted? (a) As soon as possible (b) after 2 min of external massage (c) After 3–5 min of external massage (d) After 5–10 min of external massage (e) Only after continued cardiac arrest despite emergency re-sternotomy (f) Only in exceptional circumstances and should not be part of routine cardiac arrest management after cardiac surgery
10	If you had to name a number of defibrillation attempts or a rough time at which you felt that a patient less than 24 h after cardiac surgery in ventricular fibrillation should have emergency re-sternotomy what would it be? (number of attempts and number of minutes)
11	If you had to name a number of defibrillation attempts or a rough time at which you felt that a patient MORE than 24 h after cardiac surgery in ventricular fibrillation should have emergency re-sternotomy what would it be? (number of attempts and number of minutes)
Cardiac arrest where the rhythm is not VF or pulseless VT	
12	With regard to patients who arrest after cardiac surgery but the rhythm is not ventricular fibrillation or ventricular tachycardia. In how many minutes should emergency re-sternotomy be performed if the patient is WITHIN 24 h of surgery?
13	With regard to patients who arrest after cardiac surgery but the rhythm is not ventricular fibrillation or ventricular tachycardia. When should emergency re-sternotomy be performed if the patient is MORE THAN 24 h of surgery?
14	For patients with a non-VF/VT cardiac arrest less than 24 h after surgery, after atropine and pacing have failed and massage has continued for over a minute, what factors would prevent you from performing an immediate chest reopening? (text response)
Emergency re-sternotomy: technique	
15	With regard to emergency chest re-opening (a) A surgeon should always perform this and non-surgeons should never do this (b) If no surgeon is available rapidly then you would be happy for a non-surgeon to perform this if trained to do it (c) if no surgeon is available rapidly then you would be happy for a non-surgeon to perform this even if they have had no formal training
16	In the exceptional circumstance where no surgeon is immediately available to perform the emergency re-sternotomy in an arrest, who would you be happy to do this instead? (multiple responses allowed) (a) An anaesthetologist (b) A surgeon's assistant (c) A theatre nurse (d) A junior doctor (e) A senior intensive care nurse (f) Nobody except surgeons should do this
Training and arrest protocols	
17	In your unit do you practice and provide training in the process of emergency chest re-opening with your staff in the intensive care? (a) We never practice, and this is not necessary (b) We never practice this but this might be a good idea

- (c) We talk about this informally to our staff and they have experience of this  
 (d) We have occasionally practiced this  
 (e) We regularly practice this
- 18 With regard to our current guidelines for resuscitation for patients who arrest in the cardiac intensive care unit  
 (a) I advocate current resuscitation guidelines as proposed by the European Resuscitation Council or the American Heart Association on our unit  
 (b) I do not agree with current resuscitation guidelines and we have our own agreed protocol on our unit  
 (c) I do not agree with current resuscitation guidelines. I would act as I see fit, although we do not have our own agreed protocol on the unit  
 (d) I have not actually read either of the European resuscitation council or AHA 2005 updated guidelines on resuscitation
- 19 With regard to staff training for cardiac arrest after cardiac surgery in the intensive care  
 (a) Current training available is adequate despite it not being tailored to patients after cardiac surgery and no further training is needed in our unit  
 (b) We give additional training tailored to patients after cardiac surgery and no additional training is needed  
 (c) Training tailored to patients after cardiac surgery may be useful for our staff in the future  
 (d) Training tailored to patients after cardiac surgery is important and should be given in the future

the clinical guidelines committee and the CTSNet editors (R.L.E and R.K.O.) this was reduced to 19 key questions (Table 1). The survey was hosted on CTSNet from the 21st of December 2007 to the 8th of June 2008 and was promoted on the front page of the website and via a blog page.

### 2.1. Respondent entry criteria

In order to get maximal completion the decision was made to make access freely available to all users. A total of 90% of the 24,000 members of CTSNet are cardiothoracic surgeons and thus it was felt that the vast majority of respondents would be practising surgeons. However based on experience from previous surveys, it was viewed that locking the survey behind the CTSNet login password or requesting personal details about the respondent would significantly reduce the completion rate.

### 2.2. Demographics

The Internet protocol (IP) address was recorded from each respondent and the country of origin determined from this and collated for analysis. The first five questions were used to obtain demographic data on the size of the unit and also the prevalence of cardiac arrest and emergency re sternotomy in the unit where the respondent worked.

### 2.3. Data cleaning

Prior to analysis the data from all respondents were analysed independently by two researchers (Z.A. and J.D.) and excluded if the multiple choice, numerical or text responses indicated that the survey had been incorrectly completed or if multiple respondents came from the same IP address. Respondents were excluded if there were no responses to over 50% of the questions or if the numerical data responses were impossible (i.e. more arrests than operations performed in that unit).

### 2.4. Statistical analysis

Continuous data are presented as median, mean, standard deviation and range, or only as median if the data was significantly skewed using the Kolmogorov–Smirnov test. Categorical data was presented as percentages. Data was

presented and analysed using SPSS 13.0 (Statistical Package for the Social Sciences, SPSS Inc Chicago, USA).

## 3. Results

Of 387 responses, 349 were suitable for inclusion. Thirty-eight were deleted due to duplication (21 respondents) or incorrect completion (17 respondents). Twenty-five percent of respondents were from the USA, 17% from the UK and, in all, 53 countries were represented (Fig. 1).

The median number of cases performed in the units of respondents was 560 and this ranged from 45 to 5000. The percentage of cardiac arrests in these units was 1.8%, the percentage of emergency re sternotomies after cardiac arrest was 0.5% and the percentage of emergency return onto bypass was 0.2%. Respondents reported that the survival to hospital discharge of all arrests was 50% (Table 2).

With regard to a precordial thump in ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT), 28% of respondents had seen this work at least once. In addition 18% had heard of its successful use and an additional 12% would have a go even though they have never heard of a success. Only 10% felt that this might be harmful.

In patients who arrest with VF or VT, 58% of respondents would immediately commence external cardiac massage

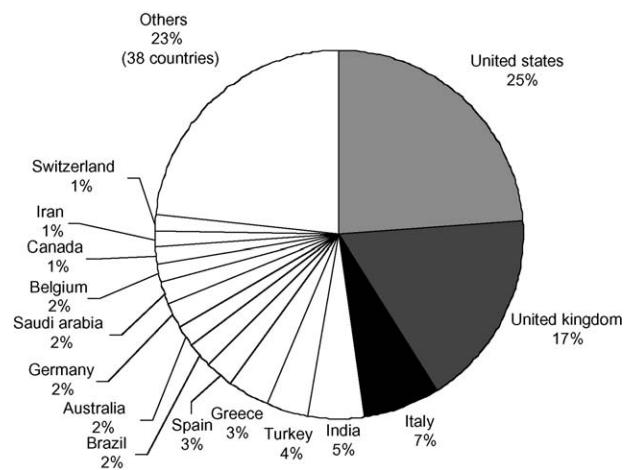


Fig. 1. Respondents by country.

Table 2  
Demographics of case volumes and arrest statistics in units of respondents.

	Median	Mean	Min	Max	SD	Percentage of total cases
Number of cases	560	702	45	5000	572	
Number of cardiac arrests	10	13	0	150	16	1.8%
Number of emergency re sternotomies	3	6	0	80	8	0.5%
Number of patients placed onto bypass	1	3	0	25	4	0.2%
Survival to hospital discharge	50%	53%	0	100	29%	50%

(ECM) while the defibrillator was prepared, with the remainder delaying CPR for defibrillation first or not responding to the question.

For patients who go into VF after recent cardiac surgery, respondents would attempt a median of 3 shocks prior to emergency re sternotomy, and would hope to do this in a median time of 5 min. They would also perform an emergency re sternotomy within 5 min if the rhythm was not VF (Table 3). With regard to the sequence of defibrillation attempts interspersed with ECM, 58% of respondents would perform three attempts at defibrillation without intervening ECM, and 54% of these respondents would then perform two rather than 1 min of ECM before further attempts. Forty-two percent would perform single defibrillation attempts interspersed with ECM, and 50% of respondents would give 1 mg of adrenaline as soon the cardiac arrest was established. Only 7% of respondents thought that it should be given rarely or not at all.

A series of questions were posed on the conduct of an emergency re sternotomy in patients who have suffered a cardiac arrest. If a surgeon was not immediately available 58% of respondents would be happy for a suitably trained non-surgeon to perform the emergency re sternotomy while 34% of respondents would not be happy for anyone except a surgeon to perform the re sternotomy. Of respondents who would allow a non-surgeon to perform an emergency re sternotomy, 30% would allow an anaesthesiologist, 76% would allow a surgeon's assistant, and 38% would allow a junior grade doctor to perform an emergency re sternotomy (Fig. 2). Only 21% would allow a senior intensive care nurse to do this.

Only 32% of all respondents advocate the current guidelines for resuscitation published by the ERC (and also the American Heart Association (AHA)) for use in their patients

Table 3  
Time to emergency re sternotomy.

	Number of responses	Median	Range
Number of defibrillation attempts before re sternotomy in VF/VT			
Cardiac arrest <24 h	349	3	11 (minimum 1, maximum 12)
Cardiac arrest > 24 h	349	5	38 (minimum 2, maximum 40)
Time to re sternotomy where initial rhythm is VF/VT			
Cardiac arrest <24 h	349	5 min	38 min (minimum 2, maximum 40)
Cardiac arrest >24 h	349	10 min	59 min (minimum 1, maximum 60)
Time to re sternotomy where initial rhythm is asystole/PEA			
Cardiac arrest <24 h	348	5 min	29 min (minimum 1, maximum 30)
Cardiac arrest >24 h	282	10 min	58 min (minimum 2, maximum 60)

and even more interestingly an additional 25% of respondents have not read these guidelines. Only 8% of units have an alternative protocol and the remainder rely on clinical expertise (Table 4).

Only 7% of units regularly practise for this emergency, with an additional 21% of respondents stating that their nurses are experienced in this scenario from clinical practise, which is why they do not practise. Seventy percent of units occasionally practise or would like to practise for cardiac arrests, and 80% of respondents thought that training specifically tailored to patients arresting after cardiac surgery was useful or important.

#### 4. Discussion

CTSNet is a not-for-profit organisation set up by the Society of Thoracic Surgeons (STS), The European Association for Cardio-Thoracic Surgery (EACTS), and the American Association for Thoracic Surgery (AATS) and now serves over 24,000 members, of whom 90% are cardiothoracic surgeons from 146 countries. On average, the CTSNet community as a whole supports over 500,000 sessions and 3.2 million page views per month and is thus the largest website in our specialty. This survey attracted 349 respondents from 53 countries and therefore represents the largest survey conducted in resuscitation after cardiac surgery.

This survey highlights the urgent need for the comprehensive guidelines presented in this issue [2]. We found that only 32% of respondents use the ERC/AHA 2005 guidelines on resuscitation in their unit [1] and of even greater concern an additional 25% of respondents admitted that they had not even read these guidelines. Only 7% of respondents regularly practise for the greatest emergency facing cardiac intensive care units, although 80% felt that tailored training and practise would be important.

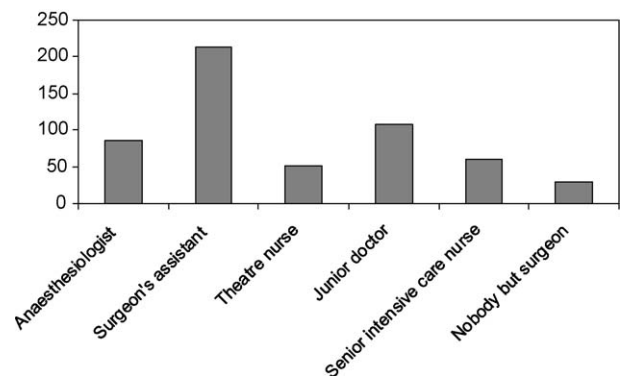


Fig. 2. Person who may perform re sternotomy if the surgeon is not available.

Table 4  
Summary of all results not already tabulated.

	Responses	Percentage
(6) Precordial thump (total)	307	
(a) Witnessed	98	32%
(b) Heard of success	63	21%
(c) Have a go	42	14%
(d) Of little use	68	22%
(e) Potentially harmful	36	11%
(7) Defibrillation or ECM for VF	307	
(a) Immediate ECM	203	66%
(b) Immediate defibrillation	104	34%
(8) Sequence of shocks for VF	307	
(a) Three attempts, 2 min ECM then single shocks	74	24%
(b) Single attempts with 1 min ECM	90	29%
(c) Single attempts with 2 min ECM	40	13%
(d) Three attempts, 1 min ECM	80	26%
(e) 3 attempts, 2 min ECM	23	7%
(9) When is adrenaline warranted	307	
(a) As soon as possible	174	57%
(b) After 2 min of ECM	65	21%
(c) After 3–5 min after ECM	35	11%
(d) After 5–10 min of ECM	6	2%
(e) Only after emergency re sternotomy	8	3%
(f) Only in exceptional circumstances	19	6%
(15) Emergency re sternotomy	282	
(a) A surgeon should always do this	96	34%
(b) A trained non-surgeon could do this	163	58%
(c) Any non-surgeons could do this	23	8%
(17) Do you train for emergency re sternotomy	277	
(a) We never practise, not necessary	10	4%
(b) We never practise might be good idea	126	45%
(c) Informal talks and experience	57	21%
(d) We have occasionally practised	64	23%
(e) We regularly practise	20	7%
(18) Current guidelines for the ICU	277	
(a) I advocate the ERC/AHA 2005 guidelines	110	40%
(b) I do not agree with these, we have our own protocol	29	10%
(c) I do not agree with these, we have no protocol	51	18%
(d) I have not read the ERC/AHA guidelines	87	31%
(19) Current training	277	
(a) It is adequate currently but not tailored	17	6%
(b) We give additional training	40	14%
(c) Tailored training might be useful	67	24%
(d) Tailored training is important and should be given	153	55%

Our study has weaknesses. We did not collate detailed demographic data on the respondents to this survey as experience on CTSNet shows that this can greatly reduce the uptake of the survey. While it would have been useful to verify the status of all respondents in more detail than their country of origin, the survey was hosted on CTSNet, a specialty specific website. Ninety percent of contact with this website has been previously verified as being by cardiothoracic surgeons, and as no other promotion of this survey was undertaken, it is reasonable to assume that the majority of respondents would also have been by active cardiothoracic surgeons. In addition there was no benefit or incentive given for completing the survey and therefore it may be further assumed that respondents may have been clinicians with an interest and experience in this area.

With regard to the incidence of cardiac arrest, emergency re sternotomy and emergency bypass, our findings correlate well with the published literature [8–15] with an incidence of cardiac arrest of 0.7–2.9% and an incidence of emergency re institution onto bypass after an arrest of 0.8% [16].

One of the most controversial issues in creating the EACTS guideline for resuscitation in cardiac arrest after cardiac surgery was whether external cardiac massage should be delayed for defibrillation in patients going into ventricular fibrillation. Our survey showed that opinion was split with 58% of respondents following the ERC recommendation that ECM should be immediately instituted. We published a structured literature review on this topic [17] which considered the potential benefits of a short period of ECM, which seemed marginal, and the potential harm of external massage on a sternotomy incision, which was of concern. It also considered whether the evidence was strong enough to recommend a major change in practice. Together with further manikin reconstructions of arrests in cardiac surgery using both protocols [5] the committee eventually decided that deferral of ECM was advisable for defibrillation or temporary wire pacing as long as this could be performed within 1 min. This topic is now the highest priority for further research prior to the updating of the ILCOR guidelines in 2010.

Linked to this a precordial thump is recommended and many respondents to this survey have either performed this with success or heard of its successful use, but due to the immediate availability of defibrillators in all ICUs, it was felt that this should not delay defibrillation or be given a high priority in the guidelines.

The survey correlated well with our structured review on the optimal sequence for defibrillation in VF [18]. Fifty-eight percent of respondents would perform three shocks without a pause for ECM, despite the fact that current ERC/AHA guidance would be for a single attempt at defibrillation followed immediately by 2 min of ECM prior to checking for an adequate cardiac output. The survey found in favour of performing an emergency re sternotomy within 5 min of the arrest or after 3 attempts at defibrillation. This finding matched well with our literature review.

Fifty percent of respondents would give adrenaline at 1 mg as soon as the cardiac arrest was established, in agreement with the ERC/AHA 2005 guidelines that recommend adrenaline as soon as possible for pulseless electrical activity (PEA) or asystole, and prior to the 3rd attempt at defibrillation for VF. Only 7% of respondents would not routinely give adrenaline. However our structured literature review [19] raised many concerns over the early administration of full dose adrenaline. No human studies in any specialty have demonstrated an increase or survival to hospital discharge with adrenaline and the ERC/AHA guidelines acknowledge that this recommendation is based on animal studies, some of which are equivocal. More importantly, the major concern of the committee was that if adrenaline was given too early and a reversible cause such as tension pneumothorax, pacing issues or tamponade was relieved, extreme hypertension might cause significant bleeding. Indeed such a case was found in the literature [20]. Thus we recommend in contrast to the survey that adrenaline only be given by senior clinicians experienced in

its use in cardiac surgery and that this would usually be after the emergency re sternotomy.

Both the survey and our literature reviews consistently demonstrate that the best outcomes in these patients who require emergency re sternotomy are obtained if this is performed within 5–10 min. Manikin reconstruction consistently demonstrates that it takes 2–3 min to perform the re sternotomy and thus if the re sternotomy is to be performed rapidly, a clinician able to perform this procedure should be available within 2–3 min. Units vary in their structure and layout in terms of the location of theatres to the intensive care and also the level of cover outside of normal working hours. Historically a senior trainee surgeon would always be resident in the intensive care unit, but increasingly with pressures such as the European Working Time Directive, and in the USA, trainee shortages, these factors have led many units to look carefully at whether other specialties or grades of clinicians can take on their role. The survey found that 58% of respondents would allow a non-surgeon to perform an emergency re sternotomy if no experienced surgeon was immediately available. However with regard to the type of clinician that could be trained to do this 76% would be happy for the surgeon's assistant to do this and 30–40% of respondents would look to junior doctors or anaesthesiologists to do this, while waiting for a surgeon to arrive. This does create major organisational issues as this would require surgeon's assistants to be resident out of hours, or for resident anaesthesiologists to be trained to do this prior to taking up a position in the cardiac intensive care unit. The clinicians who are most often at the bedside at the arrest are the intensive care nursing staff, but our survey showed that only 21% of respondents would be happy for them to perform the re sternotomy.

The survey clearly indicated a desire for structured training in the intensive care unit for this emergency. The EACTS guideline [2] recommends a key team of six people who are all well practised in their roles. The survey demonstrates the controversy as to who should be the person who performs the incision and removes the sternal wires, but it is no doubt that whether lead by a surgeon or by a non-surgeon, regular multi-practitioner simulation of the emergency re sternotomy will result in more effective resuscitation in patients who arrest after cardiac surgery. Only 7% of respondents regularly practise for this emergency but 80% felt that this would be useful in the same way that crash teams practise for arrests on medical wards and trauma teams practise in the emergency room for their most serious emergencies.

This survey supports the EACTS guideline for resuscitation in cardiac arrest after cardiac surgery, but these guidelines represent only the start of the process of improving the way in which we prepare for our most important emergency. ILCOR [4] have commenced the process of reviewing the literature on resuscitation in patients after cardiac surgery and will update their international guidelines in 2010 with a new section specifically on cardiac surgery. Thus there is still much scope for input and opinions from practising clinicians in cardiac surgery prior to this date. We hope to perform this survey again once the EACTS guidelines are established and

also we hope to engage with as many clinicians as possible to continue to improve these guidelines in the future.

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