**Hypothesis:** Trauma patients who are pulseless at the scene of injury and whose electrical cardiac activity is less than 40 beats/min cannot be revived.

**Design:** Retrospective review.

**Setting:** University hospital, level I trauma center.

**Patients:** Pulseless trauma patients who had cardiopulmonary resuscitation at the scene, en route, or in the emergency department and presented between January 1, 1991, and July 1, 1996.

**Main Outcome Measure:** Survival after traumatic cardiopulmonary arrest.

**Results:** Sixteen thousand seven hundred twenty-four trauma patients were admitted. The study cohort comprised 604 victims of traumatic cardiopulmonary arrest, 304 as a result of blunt injury and 300 as a result of penetrating injury. Transport time for the study patients was 11 ± 6.1 minutes (mean ± SD). Cardiopulmonary resuscitation was performed on them for 22 ± 11 minutes. Three hundred four patients (50%) had resuscitative thoracotomy in the emergency department; 160 patients were taken to the operating room for further resuscitation and treatment of their injuries. Sixteen patients (2.6%) survived to discharge from the hospital; 7 had severe neurologic disabilities. No patient (0/212) with electrical asystole survived. Five of 134 patients with an initial electrical heart rate between 1 and 39 beats/min survived long enough to reach the intensive care unit but died within 48 hours (4 died within 24 hours). No patient survived to leave the hospital if the initial electrical heart rate was less than 40 beats/min. All 16 survivors had an initial heart rate of 40 beats/min or greater.

**Conclusion:** Trauma victims who are pulseless and have asystole or agonal electrical cardiac activity (heart rate <40 beats/min) should be pronounced dead at the scene of injury.

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**RESULTS**

During the study, we admitted 16,724 trauma patients; 604 required CPR after trauma. Prehospital data were available for 602 of the 604 study patients (78% male; mean ± SD age, 36 ± 20 years). One half were victims of blunt injury (n = 304) and one half were victims of penetrating injury (n = 300). Transport time was 11 ± 6.1 minutes. Most of the patients had an established endotracheal airway (480/604), and CPR was performed for a mean duration of 22 ± 11 minutes. We performed a resuscitative thoracotomy in 304

CARDIOPULMONARY arrest after trauma is associated with a poor prognosis. Unfortunately, despite our best efforts, modern medicine has not come close to attaining the survival rates depicted in television programs.1 Initial reports on the use of resuscitative thoracotomy in the emergency department (ED) seemed to hold some promise for injured patients with cardiopulmonary arrest (12%-20% survival rate)2-4; however, in spite of advances in medical care, most recent reports indicate that trauma patients requiring cardiopulmonary resuscitation (CPR) have a dismal prognosis (survival rate, 0%-5%).5-11 This abysmal survival rate has led to a less aggressive resuscitative approach and a more restricted use of resuscitative thoracotomy in trauma victims presenting in cardiopulmonary arrest. Many patients are now pronounced dead on arrival shortly after reaching the ED. Eliminating the transport of patients in cardiopulmonary arrest who cannot be resuscitated would reduce the medical teams’ exposure to bloodborne diseases, conserve limited resources, and decrease costs to families, trauma centers, and society.
PATIENTS AND METHODS

Pulseless trauma patients who required CPR in the field, en route, or in the ED and presented to the University of California–Davis Medical Center level I trauma center in Sacramento from January 1, 1991, to July 1, 1996, were included in the study.

Data collected for each patient included mechanism of injury, age, sex, initial vital signs in the field and on presentation to the ED, initial cardiac rhythm, duration of CPR, transport time, ED procedures, ED disposition, length of hospital stay, and outcome. Data were obtained from the University of California–Davis Medical Center Trauma Registry and from patient medical records. We defined agonal rhythm as a cardiac electrical rate of less than 40 beats/min in a pulseless patient. Patients were considered survivors if they were alive at the time of discharge from the hospital.

Our treatment protocol for patients with cardiopulmonary arrest after trauma was constant throughout the study period. We were aggressive in performing ED resuscitative thoracotomies in patients with penetrating thoracic injuries, regardless of their physiological status. Our approach was less aggressive in patients presenting with cardiopulmonary arrest after blunt trauma or nonthoracic penetrating injuries. We did not perform an ED thoracotomy in such patients unless they had narrow complex supraventricular cardiac electrical activity.

Data were compared using Yates corrected $\chi^2$ and Fisher exact analyses for dichotomous variables. The $t$ test was used to compare continuous variables. Results are reported as mean ± SD.

patients (50%) and took 160 patients to the operating room (OR) for continued resuscitation and treatment of their injuries. After the initial resuscitation in the OR, we admitted 72 patients to the intensive care unit, 55 postoperatively and 17 directly from the ED.

SURVIVORS

Sixteen patients survived (2.6%). Four had sustained a blunt injury and 12 had penetrating wounds. Cardiopulmonary arrest caused by penetrating injury was less lethal (12 [4%] of 300) than cardiopulmonary arrest caused by blunt injury (4 [1.3%] of 304) ($P = .045$). All survivors had a sinus rhythm rate between 84 and 150 beats/min and a systolic blood pressure of 79 ± 34 mm Hg (range, 40-162 mm Hg) in the field. Severe neurologic disabilities were present in 7 of the 16 survivors. Survivors with neurologic impairments were similar to those without neurologic impairments with respect to demographics and physiological status, with the exception that survivors of blunt injury were more likely to have a neurologic deficit than were patients with penetrating injury (57% vs 0%, respectively; $P = .02$).

INITIAL FIELD CARDIAC ELECTRICAL ACTIVITY

Asystole

More than one third of patients had no cardiac electrical activity (212 [35%] of 602) at the scene of injury; 195 of these 212 patients were pronounced dead in the ED. Resuscitative efforts included ED thoracotomy in 86 (41%) of 212 patients and surgical intervention in 17 patients (8%). The 17 patients taken to surgery were pronounced dead in the OR after resuscitative efforts failed. Despite aggressive measures, none of the patients who manifested asystole as their initial rhythm survived.

Electrical Rate of 1 to 39 Beats/Min

Survival rates were equally dismal in patients with an initial prehospital cardiac rate of 1 to 39 beats/min. None of the 134 patients with an initial rate of 1 to 39 beats/min survived; 76 had an ED thoracotomy and 23 were brought to the OR. Five patients survived long enough to be admitted to an intensive care unit, but all 5 died within 48 hours of uncontrollable hemorrhage or severe head injuries (Table 1).

Electrical Rate of 40 Beats/Min or Greater

Patients with cardiac activity of 40 beats/min or greater were similar to patients who presented with cardiac electrical activity of 1 to 39 beats/min with respect to age, sex, and type of injury (blunt or penetrating) (Table 2). Patients with an initial rate of 40 beats/min or greater were more likely to have had a resuscitative thoracotomy and were more likely to have been taken to the OR for continued resuscitation. These patients also had a better response to resuscitation. Despite aggressive resuscitation (nearly half [47%] of the 346 traumatic arrest victims with a field electrical cardiac rate <40 beats/min had a resuscitative thoracotomy), we found no survivors among pulseless patients with an initial electrical cardiac rate of less than 40 beats/min.

ELECTRICAL CARDIAC ACTIVITY RATE IN THE ED

On arrival at the ED, the electrical cardiac rate was less than 40 beats/min in 455 of 604 patients. Two of these patients survived to leave the hospital (Table 3). Both had sustained a stab wound to the heart and had systolic blood pressure of 60 mm Hg at the scene of injury. One patient had cardiopulmonary arrest in the ambulance bay as he was being wheeled into the ED; he had cardiac tamponade that responded to a resuscitative thoracotomy and made an excellent recovery. The second patient had a cardiopulmonary arrest en route to the hospital. He survived with severe ischemic encephalopathy and died 4 years later of aspiration pneumonia (Table 4).

COMMENT

The cumulative reported experience with traumatic CPR indicates that successful resuscitation is rare, especially after blunt injury. As a result of the dismal outcome in pa-
tients with traumatic cardiopulmonary arrest, aggressive ED resuscitative efforts (especially the use of ED thoracotomy) have been reserved for patients with characteristics that predict a chance of survival. No effort is made to resuscitate patients who cannot be resuscitated, such as blunt trauma victims with no signs of life and victims of penetrating injury who require CPR for an extended period in the field and/or the medical control physician felt that further evaluation and resuscitation efforts were warranted.

The rapid transport of pulseless patients who are pronounced dead on arrival to the ED unnecessarily exposesprehospital personnel to the risk of bloodborne illnesses and to collision risks associated with rapid transport of trauma victims with no signs of life and victims of penetrating injury who require CPR for an extended period in the field and en route. Therefore, a large number of pulseless patients who are pronounced dead shortly after their arrival to the ED. Thus, traumatic cardiac arrest patients who could be pronounced dead in the field. Patients with asystole could be pronounced dead by the prehospital personnel based on a protocol. The decision to pronounce dead a patient with an electrical cardiac rate between 0 and 40 beats/min could be made with direction from the medical control physician. This would assure that a patient with an unusual circumstance could be given the benefit of the doubt and transported to an ED if the prehospital personnel and/or the medical control physician felt that further evaluation and resuscitation efforts were warranted.

The goal of our study was to identify trauma patients who could be pronounced dead in the field. We chose an electrical cardiac rate of less than 40 beats/min in pulseless patients. Even though we found no survivor who had initial electrical cardiac activity less than 80 beats/min, we felt that it would be difficult to justify expanding the group of patients who are pronounced dead at the scene to include those with electrical cardiac rates greater than 40 beats/min for 2 reasons. First, we had a small number of patients who presented pulseless and had a heart rate of at least 40 beats/min but less than 80 beats/min; therefore, our conclusions would suffer from a type II error. Second, we felt that it would be psychologically difficult for paramedics to pronounce patients dead if the patients had cardiac electrical activity of at least 40 beats/min. Even if our recommendations are adopted, a large number of pa-

### Table 1. Characteristics of the 5 Patients With a Prehospital Cardiac Rate Less Than 40 Beats/min Who Survived Initial Resuscitation and Were Admitted to an Intensive Care Unit

<table>
<thead>
<tr>
<th>Patient No./Age, y/Sex</th>
<th>Mechanism of Injury</th>
<th>Duration of CPR, min</th>
<th>Emergency Department</th>
<th>Length of Hospitalization</th>
<th>Cause of Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/21/M Male 36 ± 20</td>
<td>GSW heart</td>
<td>19</td>
<td>Asystole Yes</td>
<td>DIC/MOD</td>
<td></td>
</tr>
<tr>
<td>2/42/M Male 36 ± 20</td>
<td>Auto vs bike</td>
<td>17</td>
<td>Sinus tachycardia Yes</td>
<td>DIC/MOD</td>
<td></td>
</tr>
<tr>
<td>3/22/M Male 23</td>
<td>GSW heart</td>
<td>15</td>
<td>Asystole Yes</td>
<td>DIC/MOD</td>
<td></td>
</tr>
<tr>
<td>4/57/M Male 25</td>
<td>GSW leg</td>
<td>25</td>
<td>Agonal Yes</td>
<td>DIC/MOD</td>
<td></td>
</tr>
<tr>
<td>5/55/F Female 23</td>
<td>GSW head</td>
<td>23</td>
<td>Sinus No</td>
<td>DIC/MOD</td>
<td></td>
</tr>
</tbody>
</table>

* CPR indicates cardiopulmonary resuscitation; GSW, gunshot wound; DIC, disseminated intravascular coagulation; and MOD, multiple organ dysfunction.

### Table 2. Comparison of Pulseless Patients Who Had Initial Prehospital Cardiac Rates Less Than 40 Beats/min vs at Least 40 Beats/min

<table>
<thead>
<tr>
<th>Initial Cardiac Rate in Field</th>
<th>&lt;40 Beats/min (n = 346)</th>
<th>≥40 Beats/min (n = 256)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y†</td>
<td>36 ± 20</td>
<td>36 ± 20</td>
<td>.72</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>269</td>
<td>200</td>
<td>.99</td>
</tr>
<tr>
<td>Female</td>
<td>77</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>Injury type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blunt</td>
<td>159</td>
<td>145</td>
<td>.01</td>
</tr>
<tr>
<td>Penetrating</td>
<td>187</td>
<td>111</td>
<td></td>
</tr>
<tr>
<td>ED thoracotomy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>162</td>
<td>184</td>
<td>.055</td>
</tr>
<tr>
<td>No</td>
<td>164</td>
<td>115</td>
<td></td>
</tr>
<tr>
<td>Admitted from ED to ICU</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgery</td>
<td>40</td>
<td>120</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Morgue</td>
<td>305</td>
<td>122</td>
<td></td>
</tr>
<tr>
<td>Treatment/Outcome</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lived</td>
<td>0</td>
<td>15</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Died</td>
<td>346</td>
<td>375</td>
<td></td>
</tr>
</tbody>
</table>

* Unless otherwise indicated, values are numbers of patients. ED indicates emergency department; ICU, intensive care unit.
†Values are mean ± SD.

### Table 3. Breakdown of Treatment and Outcome for Pulseless Trauma Patients Based on Initial Electrical Activity of the Heart in the Field and in the Emergency Department (ED)

<table>
<thead>
<tr>
<th>Prehospital Cardiac Rate, Beats/min</th>
<th>≤40 (n = 346)</th>
<th>≥40 (n = 256)</th>
<th>ED Cardiac Rate, Beats/min</th>
<th>≤40 (n = 455)</th>
<th>≥40 (n = 149)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment/Outcome</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To OR for surgery</td>
<td>162</td>
<td>184</td>
<td>220</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>Outcome</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lived</td>
<td>20</td>
<td>0</td>
<td>2</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Died</td>
<td>346</td>
<td>241</td>
<td>453</td>
<td>135</td>
<td></td>
</tr>
</tbody>
</table>

*Values are numbers of patients. OR indicates operating room.
patients who are not candidates for aggressive resuscitation will be transported to an ED, where they will likely be pronounced dead on arrival.

In our study cohort, if victims with asystole had been pronounced dead in the field, the number of medical transports would have been reduced by 35%. If patients with agonal electrical cardiac activity (<40 beats/min) had been pronounced dead in the field, the number of victims transported would have been reduced by 57% without affecting the survival rate.

This study has several limitations. First, it is a retrospective review and has all the problems associated with such a study. The quality and completeness of the data and the potential for the authors' bias to influence the data collection process should always be considered when interpreting the results and conclusions of a retrospective study. Undoubtedly, these limitations apply to our study; however, most of the data we presented in this study were prospectively collected for inclusion in our trauma registry. Furthermore, the conclusions and recommendations of this study run counter to the institutional bias reflected by the aggressive resuscitation efforts made in these moribund patients. The second limitation is that even though this study includes a large number of pulseless trauma patients, the study might suffer from a type II error and could have missed a very small survival rate (<1%).

We should not withhold medical care from patients even when there is only a small chance that they will benefit and recover. Rendering futile care, however, should be avoided, as it does not improve a patient’s quality of life or extend life. Providing futile care consumes limited resources and makes these unavailable to other injured and/or ill patients. The unavailability of such resources may adversely affect the survival and/or quality of life of patients with a good chance for recovery. Our study was not designed to determine the cost-effectiveness of resuscitation in the moribund trauma patient; rather, our goal was to identify and eliminate futile care. Any savings, no matter how small, that result from eliminating care that cannot benefit a patient are worth recovering.

In the future, new medical and surgical therapies may improve our ability to bring traumatic arrest victims back to life; however, current therapies were unsuccessful at reviving patients who manifested asystole or agonal cardiac activity in the field. To reduce the risks to medical personnel and to preserve resources, pulseless trauma patients who have asystole or agonal electrical cardiac activity (<40 beats/min) in the field should be pronounced dead at the scene of injury.

Presented at the 106th Scientific Session of the Western Surgical Association, Indianapolis, Ind, November 18, 1998.

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Table 4. Characteristics and Functional Outcomes of the 2 Patients With an Initial Emergency Department Cardiac Rate Less Than 40 Beats/min Who Survived*

<table>
<thead>
<tr>
<th>Patient No./Age, y/Sex</th>
<th>Mechanism of Injury</th>
<th>Duration of CPR, min</th>
<th>Rhythm</th>
<th>Cardiac Rate, Beats/min</th>
<th>Thoracotomy</th>
<th>Length of Hospitalization, d</th>
<th>Functional Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/35/M</td>
<td>SW heart</td>
<td>1</td>
<td>Agonal</td>
<td>20</td>
<td>Yes</td>
<td>19</td>
<td>Good ischemic encephalopathy</td>
</tr>
<tr>
<td>2/14/M</td>
<td>SW heart</td>
<td>17</td>
<td>Agonal</td>
<td>10</td>
<td>Yes</td>
<td>37</td>
<td></td>
</tr>
</tbody>
</table>

* CPR indicates cardiopulmonary resuscitation; SW, stab wound.

REFERENCES


David R. Antonenko, MD, Grand Forks, ND: The authors very correctly point out that there is an inherent risk to health care workers when taking care of these life-threatening injuries. A number of papers have been previously published, and today’s presentation has tried to identify factors in patients where resuscitation is futile and then exclude these patients from any further health care, thus reducing the risk.

This paper addresses one issue by asking if the electrical activity of the heart can be used as a predictor for those patients who will not survive. The decision to aggressively treat this type of patient, including the use of procedures such as ED thoracotomy, must balance the probability of meaningful survival with risk to ARCH SURG/VOL 134, JULY 1999

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the health care workers, the educational value of the experience to our house staff and other workers, and the cost benefit to society, with the controversy as to what is cost and what is benefit. This is particularly true in a time of diminishing resources.

In this study, 604 patients who required CPR in the field were evaluated with equal numbers of blunt and penetrating injury. However, only 16 survived, 7 with severe neurologic injury. One question for the authors is, of those who did survive and had neurologic injury, how many were those with blunt injuries? The literature is replete with documentation showing that for patients who have CPR in the field with blunt injury, the vast majority do not survive and one must question whether or not they should be resuscitated.

It was unclear in the manuscript what the mechanism of injury was in those who did survive. I would like the authors to identify what the mechanisms of injury were in each of the survivors.

One concern, though, is the fact that the literature, starting in 1974, shows that blunt injury with asystole is associated with a very dismal, if not zero, prognosis. Yet, in their study, 212 patients with asystole were admitted, and 86 still had thoracotomy. Was this truly an intent to treat, or was this more for educational experience? If the latter, then I would suggest that needs to be reassessed.

In the paper, the authors suggest that the issue of resuscitation in the rural environment is of concern because of the limited resources, and I would strongly disagree based on the definition of rural. For those who have practiced in the rural environment, response times are frequently more than 30 minutes; in fact, in many situations, these are high-speed injuries or farming or industrial accidents and these patients almost present themselves. Consequently, I think that the impact on the rural environment is a nonentity and this is truly an urban problem.

One last question. In view of these data, has the institution that you are at now implemented some of these findings and are you now excluding the asystolic patients and those with less than 40 heartbeat from being transported? The Toronto medical education group has shown that it takes approximately 10 years for data such as these to filter down into practice. I hope this isn’t the case here.

Anthony P. Borzotta, MD, Portland, Ore: I think it is a very useful addition to the literature that indicates this is a technique which should not be done. This was addressed in Oregon, which has a statewide trauma system. It is divided into 7 area trauma advisory boards (ATABs). The ATAB-1, which is based in Portland, looked at this issue in the early ’90s and wrote instructions for the paramedics; patients who are pulseless, who had no respirations, were not even to be interrogated with a quick-look electrocardiogram (ECG). They are in fact declared dead in the field. Patients who had a pulse at any place and ECG activity were transported, and if pulse ceased in transport, then CPR was initiated and a final decision made in the ED or OR, depending upon the facilities’ resources.

Dr Antonenko made a comment about rural issues. I had looked at several hundred trauma patients who died in Central Oregon (comparing that experience to Montana, which did not have a trauma system), and, in fact, one of the more common protocol violations in that area was resuscitative attempts in patients who would have been declared dead in an urban center.

Jorge L. Rodriguez, MD, Minneapolis, Minn: One of the original thought processes in your paper was that there was a risk to the health care provider. Do you have any data on this patient population, and what was the risk to the health care provider managing the patients with ER thoracotomy?

Ronald A. Hinder, MD, Jacksonville, Fla: I would like to warn athletes with a pulse rate in the 40s that they should wear a MediAlert badge saying, “Please resuscitate if I show signs of life!”

John Barrett, MD, Chicago, Ill: I would emphasize what the authors are not saying here. They are not saying that we should abandon ED thoracotomies. They are saying it is very difficult to show that there is any benefit in in pulseless patients who have average transportation times of 11 minutes. I would argue that there is still a place for an ED thoracotomy in a patient who presents with a pulse and then loses it in the ED, especially in penetrating precordial injuries. The point I would like to make is that if we agree that there are indications for ED thoracotomies, then we have to have the team constantly physically present and the equipment present. There is a direct relationship between the outcome of an ED thoracotomy and the total number of ED thoracotomies that are performed. This was shown many years ago by Howard Champion. If that is true, I think we still need to be a little liberal in our approach towards the ED thoracotomy. The real question is, what is the downside? I agree that we need to be very cognizant of the risks of disease transmission, but in terms of costs—true costs as opposed to charges—the costs are relatively minor. The team is already present and the true cost is whatever it costs you to resterilize your thoracotomy tray and mop up the blood from the floor. The question I would have for the authors is, what do they consider to be the true indications for an ED thoracotomy?

Dr Battistella: Dr Antonenko, let me begin by giving you our bias, which is to give each and every patient every possible chance at survival. Although we keep up with the literature and are aware of the dismal survival rates reported, we felt that there were patients, at least based on anecdotal cases, who might benefit from an aggressive approach. That explains the large number of thoracotomies. We agree with you wholeheartedly that there is no place for ED thoracotomy as an educational tool.

You asked about the mechanism of injury among the survivors. Of the 16 patients who survived, 4 were victims of blunt trauma. Three survived with some disability and 1 with a severe neurological deficit.

With respect to the resources in rural areas, we have found that in some of the rural communities surrounding our metropolitan area, frequently the number of ambulances may be limited. If there is a multicasualty crash, as we might see with people traveling between the mountains and Sacramento, often the number of ambulances that can respond in a timely manner is limited. Therefore, which patients get transported first is an issue for the scene commander and potentially could make a big difference in patient outcome. If we can reduce the number of patients who need to be transported by pronouncing patients with no chance for resuscitation dead at the scene, we might improve service and outcome for other patients in the crash.

With respect to implementing our recommendations, we have begun the process. We have standardized how trauma hospitals in our region treat patients who present in cardiopulmonary arrest after trauma. With that standardized, the next step is to standardize which patients are transported to an ED.

Dr Rodriguez, we tried to quantify the risk to health care providers. Unfortunately, exposure data are maintained confidential and we were not able to extract those data from our institution. Anecdotally, we are aware of several ED personnel as well as one prehospital crew who had significant blood exposures and one ambulance crew involved in a major accident en route to the hospital with a blunt trauma CPR.

Dr Hinder, I am aware of the slow resting heart rate of many athletes. As many of you know, Miguel Indurain, the 5-time champion of the Tour de France, has a resting heart rate of 47 beats/min. I want to caution the audience that our study had nothing to do with pulse rate. Rather it focused on the pulseless electrical activity of the heart. I suspect that even the best athletes have a pulse and therefore our findings would not apply to them.

Dr Barrett, this study didn’t address which patients benefit from ED thoracotomy. Our goal was to address which patient should be transported to the ED to have an opportunity to have a thoracotomy.