대한응급의학회지 제 28 권 제 1 호
Volume 28, Number 1, February, 2017

Trauma

Emergency Department Thoracotomy with Clamshell Incision for Traumatic Cardiac Tamponade

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The emergency department thoracotomy (EDT) is a bold and challenging procedure, which may be the only chance of survival for some moribund trauma patients. EDT provides ample exposure to the injury site of the heart, enabling an effective open cardiac massage. Clamshell thoracotomy is a rapid and simple procedure that provides excellent exposure to internal structures. Because EDT has more favorable outcomes for penetrating injuries than for blunt injuries, the indication for EDT in patients with blunt trauma should be well established. Cardiac tamponade is a life-threatening condition that requires emergent pericardial decompression. EDT has been associated with successful initial resuscitation for traumatic cardiac arrest with cardiac tamponade. To date, there has not been any reports of clamshell incision via EDT for trauma patients in South Korea. Hence, herein, we describe two cases in which EDT with clamshell incision was implemented for cardiac tamponade with cardiac arrest after blunt trauma.

Key Words: Emergency department, Thoracotomy, Cardiac tamponade, Trauma

Introduction

Cardiac tamponade is a life-threatening emergency, and the treatment of choice is removal of the pericardial fluid. However, in patients with cardiac tamponade after blunt trauma, the heart is typically compressed by blood or clots, which are not effectively removed by pericardiocentesis[1)]. For patients presenting with cardiac arrest due to cardiac tamponade, emergency department thoracotomy (EDT) is often performed as a salvage maneuver[2-4)]. In South Korea, EDT, especially with clamshell incision, is rarely performed for damage control resuscitation. To the best of our knowledge, the two cases that we report herein are the first descriptions of EDT with clamshell incision in patients with traumatic cardiac arrest due to cardiac tamponade in South Korea.

Case Report

1. Case 1

A 33-year-old man sustained blunt trauma from a traffic accident. On arrival, he was comatose, and his vital signs were as follows: blood pressure, 103/51 mmHg; pulse, 128 beats/min; respiratory rate, 8 breaths/min; and body temperature, 36.0˚C. Focused assessment with sonography for trauma showed a 10-mm thick pericardial effusion with diastolic collapse of the right ventricle on the echocardiography parasternal view and no intra-abdominal fluid collection. Endotracheal intubation was immediately performed. Pericardiocentesis failed to drain the hematoma from pericardium, and his hemodynamics began to rapidly deteriorate. Subsequently, cardiac arrest occurred in 8 min after arrival. As electrical

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접수일: 2016년 9월 1일, 1차 교정일: 2016년 9월 2일, 게재승인일: 2016년 12월 2일

cardiac activity did not recover after 6 min of cardiopulmonary resuscitation (CPR), left anterolateral thoracotomy was performed shortly thereafter by a thoracic surgeon in the emergency room. Pericardiotomy was then performed, and the cardiac tamponade was relieved. The precise identification of the cardiac injury and effective cardiac massage facilitated right anterolateral thoracotomy. Finally, a bilateral anterior thoracotomy (clamshell incision) was completed by a general surgeon during open cardiac massage (Fig. 1). Superficial myocardial tearing on the right ventricle was identified after clamshell incision but did not bleed profusely. Return of spontaneous circulation was achieved 6 min after open cardiac massage. However, arrest recurred 1 min after

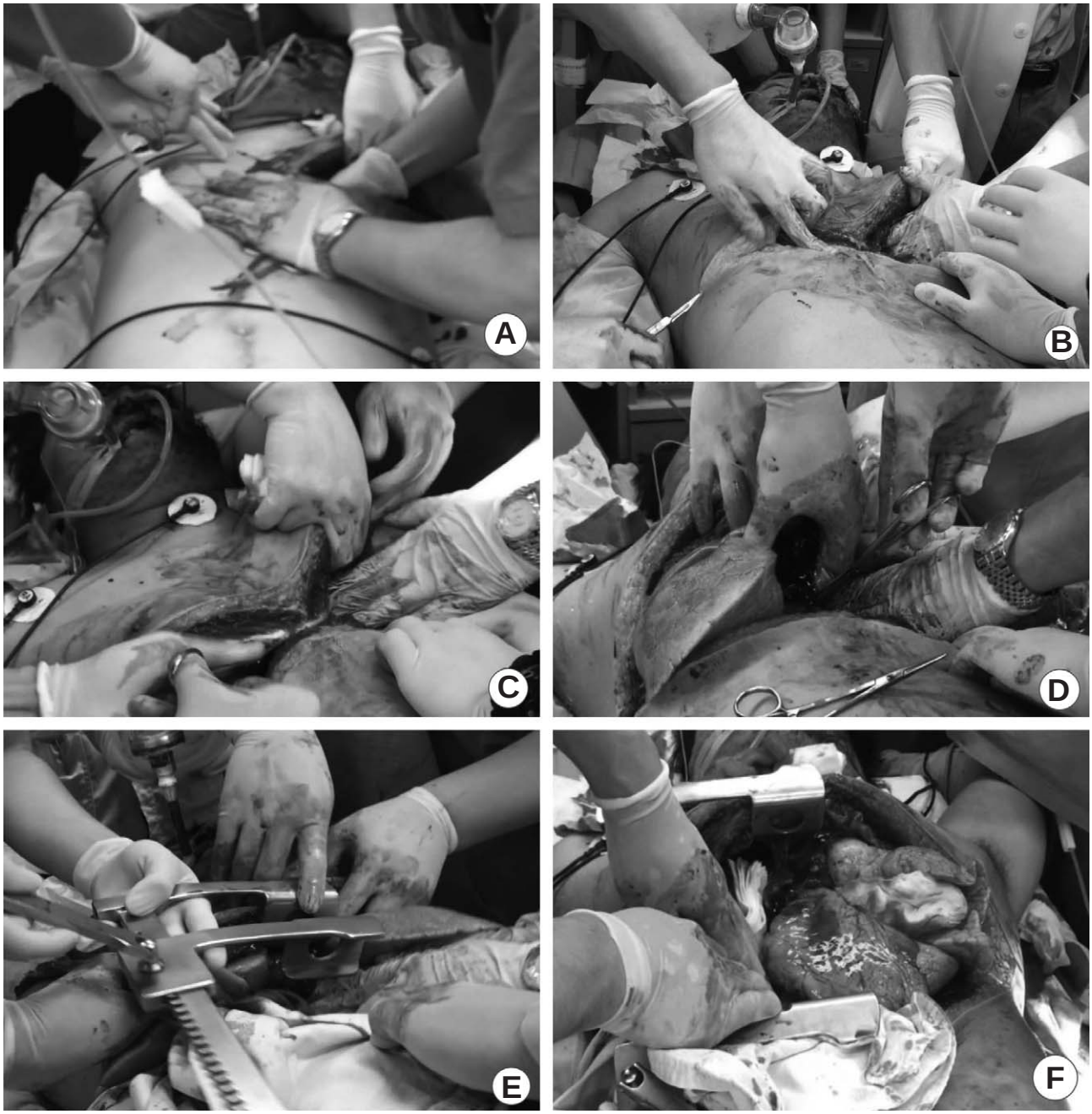

Fig. 1. Consecutive clamshell thoracotomy processes following left anterolateral thoracotomy in Case 1. (**A**) Open cardiac massage by one hand via left anterolateral thoracotomy (**B**) skin incision for clamshell thoracotomy (**C**) dividing the sternum with trauma scissors taking care to divide the inferior mammary arteries on both sides (**D**) division of fibrofatty tissue between the sternum and anterior pericardium, and pericardium (**E**) placement of the rib retractor between the cut ends of the sternum (**F**) full elevation of the sternum and excellent exposure of the heart and both thoracic cavities.

return of spontaneous circulation, and open cardiac massage was resumed. The patient was immediately transferred to the operating room, with continuous open cardiac massage but ultimately resulted in refractory asystole and was declared dead approximately 2 hours after arrival at the hospital.

2. Case 2

A 35-year-old man with blunt trauma due to a traffic accident was admitted to the emergency room by way of a local hospital, in which endotracheal intubation was performed. He was in a stupor, hypotensive, and his pupils showed a sluggish response to light at 4 mm. Focused assessment with sonography for trauma only showed a large circumferential pericardial effusion that was 15-mm thick. Cardiac arrest occurred 5 minutes after arrival. During CPR, transthoracic pericardiocentesis was performed and 20 mL of blood was drained insufficiently. Left anterolateral thoracotomy was performed in the emergency room by a thoracic surgeon as electrical cardiac activity could not be retrieved after 5 minutes of CPR. After thoracotomy, cardiac rupture was suspected by palpating the heart with hemopericardium.

Fig. 2. Clamshell thoracotomy in Case 2 (caudal side indicated by white arrow). (**A**) Bimanual technique for open cardiac massage with Kelly clamping of a lacerated right atrium and superior vena cava (**B**) primary repair with 4-0 prolene sutures at the clamping site in the operating room.

Table 1. Critical time points with regard to thoracotomy and clinical features of resuscitation

Parameters	Case 1	Case 2
Time of occurrence of cardiac arrest after arrival (sec)	480	300
Total CPR time (sec)	686	1,510
Prethoracotomy CPR time (sec)†	323	343
Time taken to perform left anterolateral thoracotomy (sec)‡	69	110
Time taken to complete clamshell incision (sec)§	124	354
Total duration of open cardiac massage (sec)‖	294	1,056
Transfer time to operating room after thoracotomy (sec)	1,380	1,740
Use of defibrillator	No	Yes†
Initial hemoglobin level on arrival (g/dL)	12.7	12.2
Blood transfusion units (RBC:FFP)	20:10	35:23

CPR: cardiopulmonary resuscitation, RBC: red blood cells, FFP: fresh frozen plasma

† Duration of CPR before skin incision for thoracotomy. ‡ The total time from skin incision until at least one hand was applied to the heart. § The total time from right anterolateral thoracotomy skin incision until application of two hands to the heart. ‖ Shocks of 30 J during open cardiac massage.

Contralateral extension of the thoracotomy was then directly performed by a thoracic surgery resident owing to adequate exposure of the heart. After completion of clamshell thoracotomy, a large amount of blood gushed out constantly from the right heart when performing pericardiotomy. An approximately 5-cm long laceration was observed from the superior vena cava and right atrium, and temporary bleeding control was achieved by closing it with Kelly clamps (Fig. 2A). After clamping, electrical cardiac activity was returned after 20 minutes of open cardiac massage, and the patient was transferred to the operating room. Although primary repair of the injured site was performed (Fig. 2B), the lethal triad (hypothermia, coagulopathy, and acidosis) developed and was not controlled. Consequently, the patient died 5 hours after arrival at the hospital due to uncontrolled bleeding and multiorgan failure. Procedural points in time, transfusion volumes, initial hemoglobin levels, and a use of cardioversion for both patients are described in Table 1.

Discussion

EDT is a high-risk, low-survival procedure that attempts to salvage patients who have sustained traumatic cardiac arrest. As in the above two cases of cardiac tamponade, EDT may be a life-saving option because life-threatening hemodynamic compromise is not compatible with survival during conventional CPR and transfer to the operating room. Since 1970, there has been a dramatic decrease in the rate of pericardiocentesis with a concurrent increase in EDT. As a result, pericardiocentesis for traumatic cardiac tamponade has only been a bridging intervention for temporary decompression followed by thoracotomy[1]. Thoracotomy offers relief of pericardial tamponade, a potential way to deal with bleeding, and the possibility of internal cardiac massage[5]. Since the first description of EDT in 1967[6], it has remained a controversial procedure associated with limited salvage rates and potential risks. Although EDT has several survival predictors, such as injury mechanism, anatomic injury location, degree of physiologic derangement by performance of prehospital CPR, presentation of signs of life, cardiac rhythm, or vital signs, the hospital survival rate for patients presenting pulseless to the emergency department after penetrating thoracic injury has been shown to be significantly higher after EDT (21.3%) than without it (2.8%)[7]. In addition, long-term survival associated with this procedure ranges 10%-30% for penetrating trauma and 0%-2% for blunt trauma, regardless of clinical status on presentation[3,7,8]. Although there is a general consensus that EDT is a procedure best reserved for patients with signs of life upon arrival to the trauma center, discrepancies in recommendations for the appropriate use of EDT indications in patients with cardiopulmonary arrest remain[9]. Meanwhile, the Western Trauma Association suggests indications for EDT based on a prospective multicenter trial which predicts productive survival in patients that (1) sustain blunt trauma with less than 10 minutes of prehospital CPR and no signs of life or (2) penetrating torso trauma with less than 15 minutes of prehospital CPR and no signs of life[10-12]. In the current two cases, both patients had cardiac tamponade with blunt trauma and underwent less than 10 minutes of CPR with no signs of life after being admitted to our trauma center. Thereafter, EDT was performed according to the Western Trauma Association algorithm.

Clamshell thoracotomy for traumatic cardiac arrest is a time-dependent procedure, both rapid and simple to perform, and provides excellent exposure to internal structures. Among several emergency thoracotomy incision methods, many surgeons have demonstrated that a stepwise approach to EDT incisions, starting with left anterolateral thoracotomy and extending to a clamshell incision if necessary, may be a reasonable approach based on clinical presentation[11,13]. Others have suggested that clamshell incision may be a standard, initial EDT incision and superior choice for rapid access and control of all thoracic structures, especially for patients arriving at the hospital in extremis[14,15]. Although stepwise incision was used in our two cases, clamshell thoracotomy for patients in extremis could provide excellent exposure to internal structures for assessment of cardiac injuries and provide an avenue for effective open cardiac massage.

In South Korea, EDT and clamshell incisions remain somewhat unfamiliar procedures and are not favorably employed for several reasons. First, South Korean trauma medical systems were only recently adopted, and trauma resuscitation strategies, such as damage control resuscitation, medical team approach, etc., have not yet been constructed. Second, since injury mechanisms of trauma

patients in South Korea are mostly blunt[16], and EDT for blunt trauma patients has very poor outcomes relative to penetrating injuries, many physicians may be pessimistic about EDT. Third, there is a lack of systematic training to master surgical procedures for trauma, even for trauma surgeons, which is stagnating the trauma system in South Korea. Fourth, the supply and quality of equipment and environment to carry out EDT in the emergency department are insufficient. In our Case 1, both thoracic and general surgeons who performed thoracotomy were trauma surgeons and have been practicing thoracotomy along with clamshell incision in experiments with over 20 swine models. On the other hand, in our Case 2, the resident thoracic surgeon had not received prior educated on the procedure. Consequently, total the procedure time was shorter in Case 1 than in Case 2. Puchwein et al.[17] reported that nonsurgical trainees performed clamshell thoracotomy on a cadaver in 167 seconds (mean) with similar to experienced surgeons through education and hands-on experience. London's Air Ambulance which is staffed by non-trauma surgeons published data on 71 prehospital thoracotomies using a clamshell technique and reported the survival of 13 patients[18]. In other words, clamshell thoracotomy can be sufficiently performed by nonspecialists and provide a significant probability of survival. In addition, each team that performs EDT should consist of two or more with experience and expertise. Also, we believe that the preparation of equipment including rib spreader for EDT could reduce the procedural duration of EDT.

In summary, we report two cases of emergency department clamshell thoracotomy for blunt trauma with cardiac tamponade and cardiac arrest in a South Korean level 1 trauma center, although the patients did not survive. EDT, along with clamshell incision, for select trauma patients in extremis may be a valuable procedure providing a last chance of survival. If systematic training through trauma-specific education programs is provided to clinical physicians and trauma surgeons alike, and a South Korean consensus guideline for EDT is achieved, the probability of survival with EDT, even in blunt trauma patients, may be expected.

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