Volume 6
Issue 1
January 2022
ISSN:5101195-3

KOSOVA JOURNAL OF SURGERY

PAPERS PRESENTED AT THE FIRST CLINICAL CONGRESS OF THE KOSOVA COLLEGE OF SURGEONS SEPTEMBER 24-26, 2021

KOLEGJI I KIRURGËVE TË KOSOVËS
KOSOVA COLLEGE OF SURGEONS
MMXVIII

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Thoracic Trauma

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Abstract

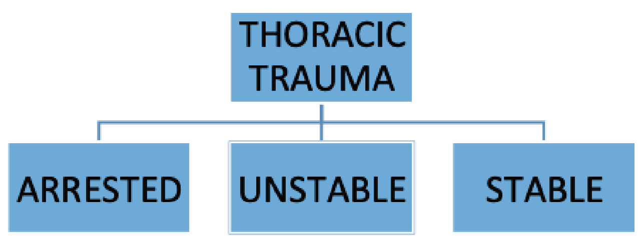
Given that thoracic trauma is a broad topic, this essay narrowed its focus on the topics of enhanced knowledge. More precisely on the topics of emergency department resuscitative thoracotomy (EDT), penetrating cardiac injuries, chest tubes, auto-transfusion, and sternal fixations among these three groups of patients: arrested patient, unstable and stable patient.

Keywords: Thoracic Trauma, EDT, Arrested Patient, Unstable, Stable

Introduction

As the topic of thoracic trauma is vast, this essay will concentrate only on the topics of enhanced knowledge, defined as areas in which I have published already. Therefore, the topics will be limited to emergency department resuscitative thoracotomy (EDT), penetrating cardiac injuries, chest tubes, auto-transfusion, and sternal fixations.

When treating patients with thoracic trauma, my first thought process begins with dividing these patients into three groups. Thus, the algorithm in my mind starts with whether the patient has arrested, is unstable, or is stable. To put it in simpler terminology, this means: are they dead, dying, or not going to die.



I. Arrested Patient

Let us first address the arrested or dead patient. While this may seem intuitive and obvious, in reality to determine whether a person is dead or not is not so easy, as it has to be done in a matter of seconds and the urgency is high. Often, the EMS will bring these patients into the hospital while performing CPR. The first difficult task is to stop performing CPR, and, within one-minute, to try to determine if the patient is dead. This will seem uncomfortable knowing that there may be no perfusion to the brain during this time, because CPR has been suspended.

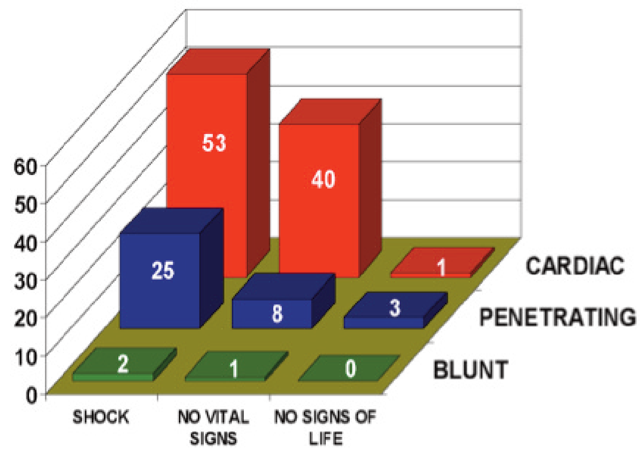
Nonetheless, you need to keep in mind that external CPR and chest compressions on an exsanguinated patient are not effective and do not pump blood to the brain. In addition, the trauma team tends to react more slowly and is often complacent, since the team members seem to get the impression that the external cardiac compressions are indeed perfusing the brain.

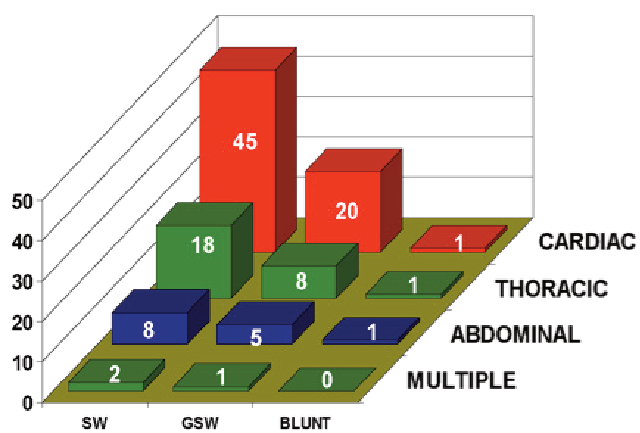
Therefore, when you stop CPR, your team tends to react faster and with more urgency.

Determining if a patient is dead or not has to be done as quickly and accurately as possible. Obviously, if they came in with a label that they are dead and have no chance of resuscitation, this would be easy. Even if they did come this way, it still must be confirmed, as there are scenarios where the patient is not dead or is salvageable. Assuming that you are not by yourself, and that you have your trauma team, one person needs to hook the patient up to an electrical cardiac monitor, while another tries to obtain a blood pressure. Others must simultaneously check for a pulse, breathing activity, and, if at all possible, you, or someone else, need to put an ultrasound probe on the chest to see if the patient has any cardiac activity. This Focused Assessment with Sonography for Trauma (FAST) scan needs to be done quickly and efficiently. You obviously cannot perform an ultrasound when someone is doing external compressions, and this is another reason for suspending CPR during trauma resuscitations. Doing this is very stressful as it takes time, at least 15 seconds, even when prepared. If prepared, the absence of any signs of life, including electrical activity, takes a seemingly long time.

If the patient is dead, there are additional questions that need to be asked and answered. These questions are HOW did the patient die, WHEN did they die, and WHAT do you think was the main source of exsanguination. The reason to ask these questions is that if the person is dead, you have to decide rapidly whether or not the patient warrants an emergency department thoracotomy.

This review paper published 20 years ago in the *Journal of the American College of Surgeons* conveyed that these 3 questions of how, when, and why, relating to the death of a patient, will help you decide whether or not to try and perform an EDT.[1]





At the time of this study, none of the literature found looked at these three variables together. They all looked at one or two of the three variables, but not all three at the same time. The HOW is referring to the mechanism. With a blunt trauma, such as a car accident or a pedestrian struck by a vehicle, there is a very low survival rate as compared to a gunshot wound, which is still very lethal, or the mechanism of a stab wound, which has the highest survival rate.

The second question is WHEN did they die? Was it in front of you and the resuscitation bay, or was it 10 minutes ago during transport, or did it occur a while ago? This impacts survival, and, thus, my decision as to whether to perform an

EDT depends on the answer to this question. The third and final question is which large blood vessel did the patient bleed out from. And, is this answer, typically, your best guess? It turns out that having to fix the heart results in the highest rate of success, other thoracic bleeding is the second best result, and if the bleeding is from below the diaphragm, the success rate is the lowest. Therefore, depending on the answers to these three questions, I will decide whether to perform an emergency department thoracotomy.

Another publication regarding EDT showed that there were some changes in terms of how often EDT was performed in the United States. The aim of this study was to analyze the utilization and survival trends during the past 5 years, as well as factors that influence survival after EDT. By examining data from adult patients (greater than 18 years old) that underwent EDT in the American College of Surgeons Trauma Quality Improvement Program, it was evident that out of 2,229 patients that underwent EDT, the overall survival rate was 9.6%. The EDT utilization rate has decreased from 331/100 000 to 243/100 000 trauma admissions, and the survival rate has improved from 7.9% to 11.3% ($p<0.001$). The conclusion from this study showed a trend towards a more careful selection of who should undergo EDT, which might be the reason for the improved survival rate. Specifically, the study also suggested that EDT on patients aged >60 years with a blunt MOI, or on any patient aged ≥70 years regardless of MOI, is futile and should be avoided.[2]

Some clear contraindications for EDT in our institution are: if the mechanism is blunt trauma, and the patient has no cardiac activity on FAST, then EDT is futile; therefore, EDT is not performed (EDT is contraindicated). For penetrating trauma, if death occurred due to numerous gunshot wounds, it involves the abdomen, and there is no cardiac activity, we will withhold EDT (EDT is contraindicated). If the mechanism is a stab wound and the patient had signs of life within 10 minutes of arrival, I would consider performing an EDT (EDT is indicated).

An additional tip regarding the approach to penetrating injury is that upon the primary survey, we perform the typical ABCDE backwards or in reverse order. Although the primary exam and management are done simultaneously, the priority, first, goes towards the exposure of the patient. All the decisions will be based on identifying the injuries. This starts with where the holes are present on the patient. We must view all of the skin in order to estimate what might be injured. All my decisions depend on where the holes are located. Second, we note whether the patient is moving arms and legs. This determines if they have a neurologic deficit or not. If the spontaneous movements of the extremities are symmetrical, we are no longer concerned about brain or spinal cord injury. Noting this takes only seconds and is not detailed.

Third, we then check their circulation, announce the quality of the pulses, and note the presence or absence of anxiety, which may indicate hemorrhage. As soon as the first manually obtained blood pressure is announced, we note whether the shock index is greater than one. Shock index is defined as heart rate mathematically divided by systolic blood pressure. This is not so complicated, because a shock-index of greater than 1 just means that the heart rate is greater than the systolic blood pressure. This is a sign of hemorrhagic shock.

Fourth, we worry about breathing and airway. The rationale is that if they had airway or breathing problems, they would have manifested this in the field. It is unlikely that these two issues would be *in extremis* in the trauma bay upon arrival. . If they made it to me thus far, they would stay alive for the next 30 seconds, and, if they had airway problems, they would be dead by now.

With regard to exposing the patient, the process can be done quickly. The patient must be rolled right away in order to look at the back. During this time, the technicians will place the leads on for detection of electrical activity. A nurse will obtain a manual blood pressure, while another nurse places and obtains IV access. Following, the FAST ultrasound is performed; and if the decision to perform a thoracotomy has been made; that is, when the intubation process will start. If the decision to perform an EDT has been made, we will perform three simultaneous procedures; first is oral intubation; second is obtaining a central line; third is insertion of a right chest tube. All these tasks must be previously assigned before the arrival of the patient. Obviously, if you do not have a full staff, these tasks need to be delegated and prioritized. Once these procedures have been initiated, it is nearly impossible to see the back of the patient to determine where the penetrating injuries are located. Thus, the opportunity to look at the back occurs before the procedures start. Hemorrhage control depends on identification of the injuries, so looking at the back helps to determine where the injuries could be. The injury could be solitary and in the left chest, or it could be numerous to the entire torso and below the diaphragm. This type of information is critical in my decision as to whether or not the patient is going to undergo an ED thoracotomy. And, again, that is why it is critical to still see the patient's full body before making a decision. I have witnessed numerous EDT, where the surgeon has not seen the patients back and does not know where the source of bleeding may be. They only know how to do the procedure, but novice surgeons that make this mistake have not had many survivors.

Again, it is imperative to examine the back of the patient, because it aids in making a determination; for example, if the GSW is isolated to the right chest, it would help determine my suspicion of the source of hemorrhage differently. If I thought the source of exsanguination was in the right chest, I may decide to open the right chest before opening the left, or I may be quick to perform a clamshell thoracotomy. If this patient looks like she was shot below the diaphragm and in the abdomen, I may decide not to perform an EDT. I already know that the exsanguination source, being below the diaphragm, is going to cause the patient to be unlikely to survive and, thus, I may decide not to perform an EDT.

The previous publication was used to generate these guidelines from the Eastern Association for the Surgery of Trauma (EAST) and the conclusions were basically the same.[3] The bottom line was that, in rare scenarios, patients, who have arrested, may be a candidate for EDT if they lose signs of life in the ED, but, otherwise, EDT is contraindicated, if the mechanism of injury was blunt trauma.

In a similar way, a study, done in Seattle, Washington on the topic of survival after penetrating cardiac injuries, examined epidemiological data and not just hospital outcome results. There was one similar study performed 30 years ago in Dallas Texas.[4] This study depicted that we had not really made much progress over the past 30 years, even when comparing to the development of sophisticated trauma systems and centers. In general, if you suffered a gunshot wound to the heart, the survival rate was 10%, and, if the patient suffered a stab wound to the heart, the survival rate was 33%. In the United States, if you survived long enough to get to the hospital, then the survival rate goes up to 30% for gunshot wounds and 53% for stab wounds. Interestingly, the highest hospital survival rates published were from countries with poorly developed trauma systems. This is because the severely injured patients, typically, do not survive long enough to get to the hospital. There is, thus, a selection bias as the more stable patients with the more minor injuries make it to the hospital to be treated. As expected, patients that survive penetrating injury to the heart will have long term complications.[5]

II. Unstable Patient

For the unstable patient, who is in the process of dying, you will not have time for CXR or ultrasound. With penetrating thoracic trauma, a time-tested guideline is that you should put in bilateral chest tubes to determine which chest you may have to open, if they have ongoing bleeding. Nonetheless, during the process, the chest tubes may be all that is needed. In penetrating trauma, more than 95% of the time, a chest tube will suffice, and may be the only intervention needed other than resuscitation. The multicenter study has shown that thoracotomy is needed only in 5% of penetrating thoracic trauma and in less than 2% of blunt trauma.

Tension pneumothorax is a condition that occurs when a pneumothorax causes enough pressure in the thoracic cavity to cause cardiogenic shock. The point is that while pneumothorax may be common, tension physiology is very rare. However, if the circumstance were to occur, the current recommendation is to perform a needle thorascopic decompression with a large angiocatheter.

While the indications may make sense, the policies have resulted in many patients having an attempted needle decompressive thoracostomy tube placed by EMS and ED physicians. The problem is that this action may cause two additional problems. Firstly, the success rate of the needle entering the chest is only about 50% of the times. Therefore, it does not complete the intended task. In the *Journal of Trauma* article, published recently by Dr. Matthew Martin, it was found that 26% of needle thoracostomies demonstrated mechanical failure due to kinking, obstruction, or dislodgement. The disadvantage of the angiocatheter, being used to decompress the pleural space, is that when the inner sharp needle is removed, plastic angiocatheter remains. It renders the angiocatheter ineffective. Another disadvantage is that if the patient does not have tension pneumothorax, the procedure will cause a pneumothorax or injury to the lung. Therefore, the first advice is that the needle thoracostomy should only be done if the patient demonstrates tension physiology. It is not based on whether the patient just had a penetrating injury to the chest. The patient should have difficulty with respiration, oxygenation, or be in shock.

For this problem, we have previously suggested a modified varees needle that is attached to a patented one-way valve with flow indicator. The modified varees needle has a locking mechanism that places the blunt tip to protect the lung from the sharp introducer needle This device allows for passage of a guidewire, so that a small 14 F chest tube can be inserted by using the seldinger technique over the guidewire. This device is still under development. In a busy, noisy environment, it is difficult to see if the air is going in or out of the needle thoracostomy angiocatheter. And, thus, this development has made it easy to visualize when the air is coming out. This device also is a one way valve, so that air cannot enter the pleural space. (Figure 2)[6].

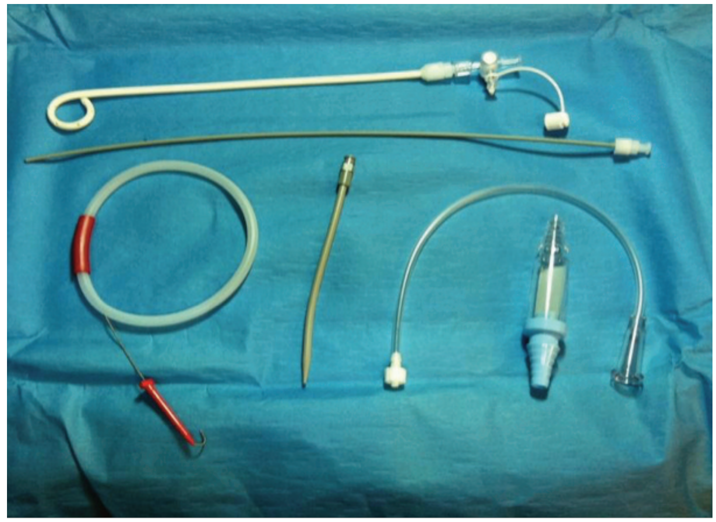
With regard to the stable patient with a thoracic trauma, another concept that we have published on is giving the shed collected blood from chest tubes back to the patient. This is called "autologous transfusion." Historically, because of several studies that were ex-vivo and bench-top research, it raised a concern that it might cause iatrogenic coagulopathy. However, in a clinical study, we were able show that giving patients their own shed blood back is safe and easy, and saves money. We were able to demonstrate that it did not cause clinically significant coagulopathy. For resource limited scenarios, autologous transfusion would be very helpful. The collection devices commonly sold have collection chambers specifically designed, sold, and marketed to perform autologous transfusions. If the devices are not available, the shed blood can be collected in any device as long as it is sterile and the blood transfused is filtered with common blood filters. Anticoagulants such as citrate phosphorous dextrose (CPD) can be used, but it is not essential. The amount of CPD used should be 50cc per 500cc of blood.[7]

III. Stable Patient

A relatively new concept, when treating stable patients with thoracic trauma that is growing in popularity, is the use of small-bore chest tubes. Although many trauma centers and classic teachings have customarily advocated the use of large chest tubes for hemothoraces, studies have shown that this is not necessary. The chest cavity has an abundance of tissue factor, which causes clotting of free pleural blood to decrease bleeding. This has historically led surgeons to place larger and larger chest tubes. Many trauma centers have advocated the use of 40 F chest tubes for traumatic hemothoracies. Some centers even advocated putting in second tubes, if the diaphragm were not visualized on the follow up chest X-ray after the placement of the first tube. The inability to visualize the diaphragm was interpreted as incomplete evacuation of the hemothorax and it resulted in the placement of a second chest tube. Some institutions also advocated a policy of a second chest tube even if the chest tube output were greater than 400cc of blood.

Published studies have shown that liquid blood, which has not clotted will come out of any size chest tube. On the contrary, clotted blood will not come out of any size chest tube. The first study demonstrating this concept in trauma patients was done in Los Angeles County Medical Center, which is a busy urban trauma center. They compared the results of placing a 28 F chest tubes compared to larger chest tubes, such as 36 F chest tubes.[8] The results showed that the drainage was equivalent in the smaller sized tubes as compared to larger sized chest tubes. Subsequent studies went further to examine the effectiveness of the 14 French chest tubes.[9,10] There is a convenience kit that allows for the placement of 14 French chest tube using the Seldinger technique. It was found to be useful because of the decreased amount of pain and trauma to the patient.

Figure 3.



Pain caused by placement of open chest tubes is well-known. Numerous studies, ranging from case series, to prospective studies, and to finally multicenter prospective studies, showed that small bore chest tubes (14F) worked well for pneumothoraces and for hemothoraces. The complication rates between the Seldinger technique and open large bore technique have been found to be equivalent. The need for video-assisted thorascopic removal of retained hemothoraces were also found to be equivalent.[11,12,13,14,15] The next exciting area of research currently undertaken is the draining and irrigating of chest cavities for patients who have hemothoraces.

Finally, another concept for the stable patient with thoracic trauma regards sternal fractures. Modern surgery now offers internal fixation for numerous orthopedic injuries. Rib fixation has also increased in recent years. However, the topic of rib fracture fixation is complicated and ill defined. Thus, I will avoid commenting on this topic as the indications are not yet known. However, with regard to sternal fractures, it can be shown that stabilization causes almost an immediate reduction in pain and discomfort.[16] There are numerous sternal plating systems available. In our institution the indication that is used for open reduction and plating of sternal fractures is severe pain causing inability to mobilize. There may be slightly displaced sternal fractures, but if it does not cause pain, we generally do not advocate the plating of these fractures. However, there are many patients who have sternal fractures with or without displacement, have severe pain, and cannot mobilize out of the bed. For these patients, we offer a small cutdown and placement of rib plating. In our experience, this has been received well and with minimal complications.

Conflict of Interest Disclosure Statement

The author has no conflict of interest to disclose.

Figure 4.

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