



Trans-mediastinal Gunshot Wounds: Are “Stable” Patients Really Stable?

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Abstract. Gunshot wounds that traverse the mediastinum frequently cause serious injury to the cardiac, vascular, pulmonary, and digestive structures contained within. Most patients present with unstable vital signs signifying the need for emergency operation. An occasional patient will present with stable vital signs. Work-ups for such a patient may range from surgical exploration to radiographic and endoscopic testing to mere observation. We report our experience with diagnostic work-up of the stable patient with a transmediastinal gunshot wound. All stable patients who present to our urban level I trauma center following a transmediastinal gunshot wound undergo diagnostic work-up consisting of chest radiograph, cardiac ultrasound, angiography, esophagoscopy, barium swallow, and bronchoscopy. The work-up is dependent on the trajectory of the missile. Information on these patients is kept in a prospective database maintained by the trauma attending physicians. This database was analyzed and comparisons were made using Student's t-test and the Fisher exact χ^2 as appropriate. Over a 68-month period, 50 stable patients were admitted following a transmediastinal gunshot wound. All of these patients had a chest radiograph followed by one or more of the above tests. 8 patients (16%) were found to have a mediastinal injury (4 cardiac, 3 vascular, and 1 tracheo-esophageal) requiring urgent operation (group 1). The remaining 42 patients (84%) did not have a mediastinal injury (group 2). There was no difference between groups with respect to blood pressure, pulse, respiratory rate, pH, base deficit, or initial chest tube output. There was one death in each group, and three complications in group 2. Patients may appear stable following a transmediastinal gunshot wound, even when they have life-threatening injuries. There is no difference in vital signs, blood gas, or hemothorax to indicate which patients have serious injuries. We advocate continued aggressive work-up of these patients to avoid missing an injury with disastrous consequences.

Patients who sustain a gunshot wound to the mediastinum may present with stable vital signs and no physiologic evidence of injury. Many of these patients have an injury to a mediastinal organ that requires rapid diagnosis and urgent repair. We looked prospectively at our experience with transmediastinal gunshot wounds in stable patients. This represents one of the largest series of stable patients with these wounds.

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Materials and Methods

All patients who presented to our urban level I trauma center with stable vital signs following a gunshot wound that traversed the mediastinum in any direction were prospectively followed. Stability was defined as a pulse rate lower than 100 and a systolic blood pressure above 90 mmHg on admission or after administration of a minimal fluid bolus and placement of a tube thoracostomy.

These patients undergo diagnostic work-up beginning with a chest radiograph (CXR). Tube thoracostomy is performed for any hemothorax or pneumothorax seen on the CXR. It is then determined whether the anterior mediastinum, the posterior mediastinum, or both is at risk. If the wound is suspected of traversing the anterior mediastinum, a transthoracic echocardiogram (ECHO) is performed. If the wound is suspected of traversing the posterior mediastinum, angiography of the aorta and its branches is performed. This is followed by esophagography and esophagoscopy. Any suspicion of a tracheobronchial injury is investigated with bronchoscopy (Fig. 1).

A positive finding on any study after the CXR mandates operative intervention, with intraoperative evaluation of any remaining organs of concern. The operative approach is dictated by the structures involved. Additional diagnostic work-up such as diagnostic peritoneal lavage is done when indicated.

A prospective database of these patients was maintained by the attending surgeons and included basic demographic information, vital signs on admission, initial arterial blood gas values, diagnostic tests performed and their results, any intervention performed, findings of that intervention, and subsequent complications while in the hospital. Patients with a mediastinal injury were compared to those without using Student's t-test and the Fisher exact χ^2 as appropriate.

Results

Over a 68-month period, 50 stable patients were admitted for a gunshot wound that traversed the mediastinum. Patient age averaged 24 ± 10 years, and 94% were men. All patients received an initial CXR, which revealed a hemo-/pneumo-thorax in 47 patients (94%). Tube thoracostomy was performed in these patients,

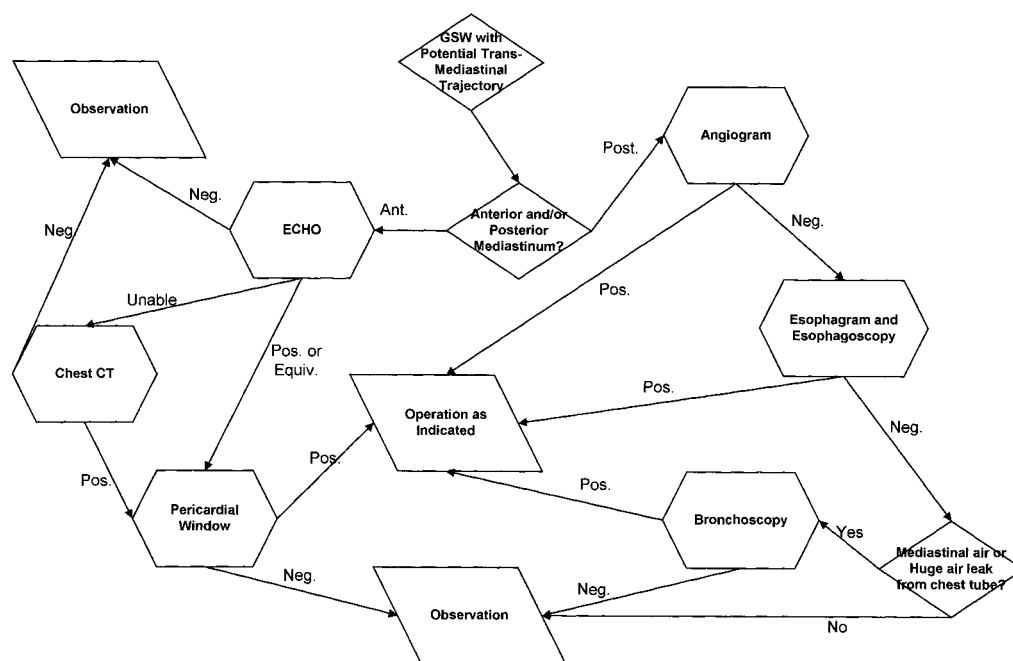


Fig. 1. Algorithm for the work-up of stable patients with a trans-mediastinal gunshot wound (GSW). Neg.: negative; Ant.: anterior; Pos.: positive; Equiv.: equivocal; Post.: posterior; ECHO: echocardiogram; CT: computed tomography.

15 of whom (30%) required bilateral tube thoracostomy with an average fluid output of 466 ± 358 cc per tube.

ECHO was performed in 44 patients, and in 12 of them pericardial fluid was seen. These patients underwent operation through a subxiphoid pericardial window which revealed cardiac injury in 4 (8%) patients and physiologic fluid in the remaining 8 patients. Angiography was performed in 41 patients and was abnormal in 3. One patient had an injury to the subclavian artery, one to the innominate vein, and the third had a combined aortic/subclavian arterial injury. Esophagoscopy was performed in 40 patients; it was negative in 39 and equivocal in one patient. Esophagography was performed in 24 patients and was abnormal in one patient, this was the patient with the equivocal esophagoscopy. Injury to the upper thoracic esophagus was confirmed at thoracotomy. Bronchoscopy was indicated in 6 patients, and no injury was found. There was one tracheal injury that was diagnosed intraoperatively in the patient who had an esophageal injury.

Not including the 8 negative pericardial windows, a total of 8 thoracic operative procedures were performed urgently: 5 sternotomies, 1 "trapdoor" thoracotomy, and 2 thoracotomies. Two of these patients had a subsequent laparotomy after sternotomy and cardiac repair. One patient had concomitant injuries of the diaphragm, liver, and stomach; the other had concomitant injuries of the diaphragm and liver. Neither of these patients had any complications. An additional 5 patients had an exploratory laparotomy as their only operative procedure for concomitant intra-abdominal injuries. Four patients had concomitant transection of the thoracic spinal cord.

The eight patients with a mediastinal injury were compared to the 42 patients without. There was no difference between groups with respect to demographics. Systolic blood pressure, pulse, respiratory rate, arterial pH, and base deficit were likewise no different between the groups (Table 1). Similarly, the need for

Table 1. Demographics, vital signs, and physiologic markers in TM-GSW patients with and without a mediastinal injury.

Marker	+ Injury (<i>n</i> = 8)	No injury (<i>n</i> = 42)	<i>p</i> -value
Age (years)	21.8 ± 4.7	24.1 ± 11.6	0.59
Sex (M:F)	8:0	39:3	0.64
Systolic BP	144 ± 30	121 ± 23	0.07
Pulse	86.9 ± 24.0	95.8 ± 23.8	0.34
Respiratory rate	21.0 ± 5.1	20.6 ± 5.4	0.85
Arterial pH	7.34 ± 0.05	7.32 ± 0.10	0.41
Base deficit	5.08 ± 2.21	5.09 ± 4.7	0.99

TM-GSW: trans-mediastinal gunshot wound; BP: blood pressure.

Table 2. Number of tube thoracostomies placed and the initial output from each in TM-GSW patients with and without a mediastinal injury.

	+ Injury (<i>n</i> = 8)	No injury (<i>n</i> = 42)	<i>p</i> -value
Patients with pneumo/hemothorax	8	39	
Right:left	5:7	28:22	
Bilateral	4	11	
Initial output (cc)	329 ± 235	466 ± 358	0.19

tube thoracostomies as well as the initial output from those tubes was no different (Table 2).

There was one death in each group (NS): the patient with an innominate vein injury exsanguinated in the operating room from decompression of the hematoma during sternotomy, and one patient died of sepsis not related to a mediastinal injury. There were 3 complications in the group without mediastinal injury: 1 patient developed pericarditis after a negative pericardial window; this was treated conservatively. Two patients required a delayed thoracotomy for evacuation of a clotted hemothorax.

Discussion

Patients who sustain a gunshot wound to the mediastinum may present with a spectrum of vital signs ranging from stable, normal vital signs to moribund [1]. Most trans-mediastinal gunshot wounds (TM-GSW) are rapidly lethal because of cardiac tamponade or exsanguination [2] and many of these patients do not live to be transported to the hospital. Of those who do survive to reach the hospital, 43% are unstable [3] and require emergency operation.

The remaining 57% of TM-GSW patients arrive at the hospital with stable vital signs. Between 35% and 60% of these patients have an injury that requires urgent repair [3–5]. There may be few clues initially that the patient has a mediastinal injury. There was little difference in physical examination, arterial blood gas, or chest tube output between our patients with and without a serious injury. These patients therefore require rapid diagnostic testing to determine if there is an injury to a mediastinal structure.

A TM-GSW is defined as any gunshot wound with a trajectory that crosses the mediastinum. This is determined by 2 wounds or 1 wound and 1 bullet on opposite sides of the thorax (right-left or anterior-posterior). TM-GSW are subdivided according to whether the anterior or posterior mediastinum (or both) are at risk of injury. The anterior mediastinum contains the heart, and is evaluated through use of transthoracic echocardiography. The posterior mediastinum contains the aerodigestive tract and great vessels and is evaluated through a combination of angiography, esophagoscopy, esophagography, and bronchoscopy.

It has been previously recommended to perform mandatory exploration in cases of TM-GSW on the assumption that any gunshot wound that traversed a major body cavity will have caused a visceral injury regardless of signs and symptoms [6, 7]. This management approach would, however, result in a greater than 40% negative thoracotomy/sternotomy rate [3]. Since the time of those recommendations, more sophisticated methods of diagnostic testing have been introduced.

Occult cardiac injuries may be present in 5% to 10% of patients after a TM-GSW [3, 5]. Transthoracic echocardiography is the diagnostic test of choice in patients with wounds traversing the anterior mediastinum. When ECHO is used to screen for pericardial fluid it is 97% sensitive, 100% specific, and 99% accurate [8]. It has the added advantage of being noninvasive and portable and can be done at the bedside without leaving the resuscitation area. In our series, 8% of patients were found to have a cardiac injury; all were diagnosed by ECHO.

Injuries to the great vessels of the posterior mediastinum may be present in up to 22% of stable patients [3–5]. The “gold standard” for evaluation of the thoracic great vessels is the angiogram. Degiannis et al. [4] recommend that this be done early during the patient evaluation because an unrecognized aortic injury may become rapidly lethal. Cornwell et al. [1] disagree, stating that an aortic injury is very unlikely in a stable patient and cites the higher incidence of complications when a diagnosis of esophageal injury is delayed. In our center, we have 24-hour angiography support and can perform both tests in under 2 hours; we preferentially obtain the angiogram first.

Esophageal injuries may be present in 15% to 30% of patients with posterior TM-GSW [3–5, 9]. Many of these patients have no signs or symptoms referable to the esophagus, reinforcing the need for work-up based on trajectory [3]. If the esophageal injury

is not diagnosed and treated in a timely fashion, the incidence of complications from mediastinal sepsis will increase [10]. Weigelt et al. showed that esophagography and esophagoscopy each miss 11% to 20% of esophageal injuries [11]; we therefore use both as complementary tests.

Tracheobronchial injuries are the least commonly found after TM-GSW, occurring in only 0 to 15% of stable patients [3–5]. These patients usually have clinical signs or symptoms suggestive of airway injury such as subcutaneous air or mediastinal air on chest radiograph. We therefore reserve bronchoscopy for those patients with clinical evidence of such injury [4].

Recent reports indicate that computed tomography of the chest (CTC) may be useful in delineating the trajectory of the TM-GSW, thus directing the work-up to only those structures not clearly shown to be outside of the path of the bullet [7]. The CTC will show the trajectory clearly in 75% of patients [2] and will potentially change the management in 67% by ruling out the need for investigation of the esophagus or aorta. In addition, the CTC is a good screening test for pericardial fluid, with 100% sensitivity, 97% specificity, and 97% accuracy [12]. The patient must be closely monitored, however, and if there is the slightest suspicion of patient instability, the patient should not be taken to the radiology suite [7, 12]. In the series of Richardson et al. [3], 7% of patients who were stable upon presentation became unstable during the course of their evaluation. It is possible that the CTC will prove useful as an initial screening test by reducing the number of invasive diagnostic procedures needed. Further evaluation, however, is necessary to determine this.

Patients with multiple injuries pose the additional dilemma of optimal timing of their diagnostic and therapeutic procedures. We had two patients in this series who had a positive ECHO in addition to indications for laparotomy. In both patients, we performed a pericardial window prior to laparotomy. Both pericardial windows were positive and repair of the cardiac injuries preceded laparotomy.

Overall, TM-GSW patients have 27% mortality after they reach the hospital [9]. Most deaths occur among patients who are initially unstable. In our series the one death in the mediastinal injury group occurred as a result of intraoperative exsanguination. Mortality in the stable patients ranges from 0 to 10% [3, 5, 9] with morbidities occurring in up to 60% of patients [1]. Our mortality rate was comparable at 4%. The presence of an esophageal injury, as well as an increasing delay to repair correlate with an increase in morbidity [1, 10]. Our morbidity rate was a low 6% and included one patient who sustained a complication (pericarditis) of the mediastinal work-up.

Conclusions

Although most patients with TM-GSW are unstable, many will present with stable vital signs and few signs or symptoms referable to the mediastinum. A significant number of them may have a life-threatening injury to the heart or great vessels as well as an injury to the aerodigestive tract that must be diagnosed early to minimize morbidity.

We recommend a rapid aggressive work-up of all stable patients with TM-GSW in order to avoid missing an injury that will have disastrous consequences.

Résumé. Les plaies par balles transmédiastinales créent fréquemment des lésions sévères des structures cardiaques, vasculaires et aérodigestives contenues dans le médiastin. Le plus souvent, les signes vitaux sont instables, indiquant une opération urgente. De temps à autre, un patient se présente avec des signes vitaux stables. Le bilan dans ce cas va de l'exploration chirurgicale à l'observation simple, en passant par les radiographies et les examens endoscopiques. Nous rapportons notre expérience du bilan à visée diagnostique chez le patient, victime de plaie par balle transmédiastinale, mais stable. Tout patient stable se présentant au centre urbain de trauma niveau I pour plaie par balles transmédiastinale a eu une séquence diagnostique comportant une radiographie, une sonographie cardiaque, une angiographie, un oesophagogramme, une oesophagoscopie, un transit baryté ou une bronchoscopie selon le trajectoire du projectile. Les renseignements concernant ces patients ont été gardés dans une banque de données prospectives maintenue par les résidents en traumatologie. Cette banque de données a été analysée et les comparaisons ont été réalisées par le test de Student et la correction du χ^2 de Fisher comme nécessaire. Pendant une période de 68 mois, on a admis 50 patients stables après plaie par balles transmédiastinale. Tous ces patients ont eu une radiographie du thorax suivie d'une ou plusieurs des investigations mentionnées ci-dessus. Huit patients (16%) avaient une lésion du médiastin (4 cardiaques, 3 vasculaires et 1 trachéo-oesophagienne) nécessitant une intervention en urgence (Groupe 1). Les 42 autres patients (84%) n'avaient pas de lésion médiastinale (Groupe 2). Il n'y avait aucune différence entre les groupes en ce qui concerne la tension artérielle, le pouls, la fréquence respiratoire, le pH, le base déficit ou le débit initial du drainage thoracique. Il y a eu un décès dans chaque groupe, et trois complications dans le groupe 2. La stabilité apparente des victimes d'une plaie par balles transmédiastinale est trompeuse: beaucoup de ces lésions menacent le pronostic vital. Ni les signes vitaux, les gaz du sang ou l'hémithorax ne peuvent indiquer à eux seuls quel patient a quelle lésion. Nous recommandons un bilan agressif continu chez ces patients afin de ne pas méconnaître ces lésions avec leurs conséquences désastreuses.

Resumen. Las heridas por bala que atraviesan el mediastino son frecuentemente muy graves pues lesionan estructuras muy importantes tales como: corazón, grandes vasos o vías aerodigestivas, contenidas en el mismo. La mayoría de los pacientes con constantes vitales inestables requieren una operación urgente. Sólo pacientes aislados presentan sus constantes vitales estables. Su tratamiento comprende desde la exploración quirúrgica hasta la mera observación, pasando por estudios radiográficos y endoscópicos. Presentamos nuestra experiencia en el diagnóstico de pacientes con constantes vitales estables tras una herida transmediastinal por arma de fuego. A todos los pacientes con constantes vitales estables que ingresan en nuestro Centro Traumatológico nivel I (ámbito urbano) con herida transmediastinal por bala se les practicó una secuencia diagnóstica consistente en: radiografía de tórax, ecocardiograma, angiografía, esofagoscopia, tránsito con ingesta de bario y broncoscopia. La secuencia de las pruebas diagnósticas depende de la trayectoria de la bala. La información así obtenida se introduce, en una base de datos prospectiva, por los residentes de traumatología. Se analiza

dicha base de datos, realizándose comparaciones mediante los test de Student o de Fisher. En 68 meses, 50 pacientes hemodinámicamente estables ingresaron en nuestro Centro, tras sufrir herida transmediastinal por bala. A todos se les realizó una radiografía de tórax seguida de una o más de las pruebas diagnósticas antes mencionadas. En 8 heridos (16%) se encontró un traumatismo mediastínico (en 4 cardíaco, 3 vascular y 1 traqueoesofágico) que requirieron una intervención urgente (grupo 1). Los restantes 42 pacientes (84%) no mostraron traumatismo mediastínico alguno (grupo 2). Entre ambos grupos no se registró diferencia alguna por lo que a la tensión arterial, pulso, frecuencia respiratoria, pH, déficit de bases o volumen de drenaje por el tubo intratorácico, se refiere. Constatamos una muerte en cada grupo y 3 complicaciones en el grupo 2. Pacientes con constantes vitales estables tras una herida transmediastinal por bala, pueden padecer lesiones que pongan en peligro su vida. No existe diferencia alguna entre unos y otros pacientes por lo que a las constantes vitales, gasometría o volumen de hemotórax se refiere. Por ello, creemos que deben de realizarse unas pruebas diagnósticas agresivas con objeto de evitar que pasen desapercibidas lesiones cuya evolución puede ser desastrosa.

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