A selective non-operative approach to thoracic stab wounds is safe and cost effective – a South African experience

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ABSTRACT

INTRODUCTION Penetrating thoracic trauma is common and costly. Injuries are frequently and selectively amenable to non-operative management. Our selective approach to penetrating thoracic trauma is reviewed and the effectiveness of our clinical algorithms confirmed. Additionally, a basic cost analysis was undertaken to evaluate the financial impact of a selective nonoperative management approach to penetrating thoracic trauma.

MATERIALS AND METHODS The Pietermaritzburg Metropolitan Trauma Services electronic regional trauma registry hybrid electronic medical records were reviewed, highlighted all penetrating thoracic traumas. A micro-cost analysis estimated expenses for active observation, tube thoracostomy for isolated pneumothorax greater than 2 cm and tube thoracostomy for haemothorax. Routine thoracic computed tomography does not form part of these algorithms.

RESULTS Isolated thoracic stab wounds occurred in 589 patients. Eighty per cent (472 cases) were successfully managed non-operatively. Micro-costing shows that active observation costs 4,370 ZAR (£270), tube thoracostomy for isolated pneumothorax costs 6,630 ZAR (£400) and tube thoracostomy for haemothorax costs 21,850 ZAR (£1,310).

DISCUSSION Penetrating thoracic trauma places a striking financial burden on our limited resources. Diligent and serial clinical assessments, alongside basic radiology and stringent management criteria, can accurately stratify patients to correct clinical algorithms.

CONCLUSION Selective nonoperative management for penetrating thoracic trauma is safe and effective. Routine thoracic computed tomography is unnecessary in all patients with isolated thoracic stab wounds, which can be reserved for a select group who are identifiable clinically. Routine thoracic computed tomography would not be financially prudent across Pietermaritzburg Metropolitan Trauma Services. Government action is required to reduce the overall incidence of such trauma to save resources and patients.

KEYWORDS

Penetrating thoracic trauma – Cost – Non-operative management – Stab wounds

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Introduction

Major trauma is the most common cause of death, disability and hospitalisation of patients under the age of 40 years.^{1,2} The World Health Organization estimates that the global injury mortality rate is five million per annum, with almost one-fifth of this occurring in Africa.³ Penetrating thoracic trauma (PTT) contributes a significant proportion of the trauma burden. A study from Cape Town quotes a national figure which estimates that thoracic trauma contributes approximately one-fifth of all non-natural causes of death in South Africa.⁴ Across the UK, PTT accounts for 25% of approximately 4000 trauma-related deaths each

year.⁵ These figures demonstrate the potential impact that PTT has on our societies and healthcare systems.

Thoracic trauma also contributes substantially to death from major trauma.⁶ A local review of mortuary data revealed an overall mortality rate of 33% for penetrating thoracic stab wounds.⁷ However, thoracic trauma is associated with a range of pathologies, from life-threatening injuries to minor self-limiting wounds. The majority of patients with PTT who reach hospital can be managed conservatively, either by observation or by means of tube thoracostomy.^{4,6,8}

Identifying patients who can safely be observed, those who require tube thoracostomy alone and those who

require surgery is key to the successful management of these injuries. When the incorrect management algorithm is followed there is the potential that some patients may have delayed surgical treatment and, conversely, that some patients may be subjected to unnecessary intervention.

Emerging imaging modalities such as a computed tomography (CT) and point-of-care sonography have been increasingly used as screening tools for PTT.⁹ Strumwasser *et al.*¹⁰, in 2016, reviewed a cohort of haemodynamically normal patients who had sustained PTT. He concluded that screening with thoracic CT (TCT) is effective in determining those who can be managed non-operatively.¹⁰ In the UK, the National Institute for Health and Care Excellence (NICE) guidelines for in-hospital management of chest trauma state, ‘consider immediate CT for young people and adults with suspected chest trauma without severe respiratory compromise who are responding to resuscitation or whose haemodynamic status is normal’.^{5,11} These guidelines make no distinction between blunt or penetrating trauma.⁵ Other authors, however, advocate choosing imaging modalities based on the findings of clinical examination.¹²

The Pietermaritzburg Metropolitan Trauma Services does not make use of routine TCT for haemodynamically stable patients presenting with PTT, but follows a selective approach. This approach eschews routine imaging of patients in lieu of stringent serial clinical examination. This approach initially developed during the era of apartheid, when the demand for trauma care greatly exceeded the available resources.^{4,8,13–15}

In response to increasing knife crime across the UK and the prominent terrorist attacks in major European and UK cities, it may be sensible to review and standardise management strategies for PTT. Gaining an appreciation for the financial burden these specific injuries place on the NHS may help to develop prudent healthcare strategies. The National Audit Office, which reviewed major trauma care in England in 2010, revealed that exact costs for the in-patient management of major trauma across the NHS does not exist. Overall estimations were quoted ranging from £0.3–0.4 billion per annum.¹ There were no cost estimations for specific injury management.

This study aims to review our selective approach to PTT and to confirm effectiveness of our clinical algorithms. Additionally, a basic cost analysis is undertaken to evaluate the financial impact of a selective nonoperative management approach to PTT. We consider the cost implications of managing the equivalent patients using the NICE guidelines.

Setting

The Pietermaritzburg Metropolitan Trauma Service (PMTS) provides definitive trauma care to the city of Pietermaritzburg, the capital of KwaZulu-Natal province. Our prospectively maintained electronic regional trauma registry (Hybrid Electronic Medical Records) was reviewed inclusively from 1 January 2012 to 30 April 2015. The Biomedical Research Ethics Committee of the University of KwaZulu-Natal provided ethical approval for this study and the maintenance of our trauma registry (BE 207/09 and BCA 221/15). Weekly morbidity and mortality meetings and stringent clinical management protocols ensure that optimal and universal care is maintained.

Management criteria for PTT

All patients presenting with PTT are seen in the emergency department. Initial assessment and management is in accordance with Advanced Trauma Life Support®. Clear published clinical and radiographic criteria are used to identify cases with a pleural collection and to determine those who would be amenable to nonoperative management (either active observation or TT) and those requiring emergent surgery. TCT is not required as part of initial radiographic work-up to determine this (Table 1).¹³ If local clinical and chest radiograph criteria are met for tube thoracostomy, this is inserted under local anaesthesia in the emergency department.

Management algorithms for PTT

The determining factor is the patient’s haemodynamic status on admission. In this paper we consider only those patients who are haemodynamically stable and who have not required surgical intervention during their admission. Figures 1, 2 and 3 demonstrate defined management

Table 1 Management criteria for penetrating thoracic injuries.	
Management	Defined criteria
Tube thoracostomy insertion	Pneumothorax > 2 cm
	Fluid level above 7th rib
Operative exploration	Haemodynamic instability
	Massive haemothorax (> 1500 ml) in initial insertion of tube thoracostomy
	Failure to respond to resuscitation
	Drainage of blood (> 200 ml/hour) + no clinical improvement
	Clinical evidence of tamponade
	Imminent cardiac arrest

Figure 1

algorithms for selective nonoperative management in PTT: active observation (for those with no evidence of visceral injury or a small pneumothorax of less than 2 cm (Fig 1, highlighted in green); tube thoracostomy for an isolated pneumothorax greater than 2 cm (Fig 2, highlighted in blue); tube thoracostomy for a haemothorax (Fig 3, highlighted in red).

For clarity, clinical assessment includes a combination of the patient’s symptoms, clinical signs and vital observations (oxygen saturation, respiratory rate, heart rate, blood pressure and temperature). This is performed serially and trends are responded to as necessary. Serial clinical assessments over a 48-hour period form the basis of our management protocol. Patients in this category are

given analgesia and observed for any clinical deterioration. On average, patients who are observed can expect to have one radiograph if normal and two if there is an isolated pneumothorax less than 2 cm. Patients who are admitted requiring tube thoracostomy for isolated pneumothorax can expect to have two chest radiographs per admission (pre tube thoracostomy and following its removal). Those patients with a haemothorax will similarly have on average two chest x-rays, provided that the haemothorax drains and resolves in full. Further

investigation and treatment would be required for those who have retained collections.

Materials and methods

Cohort and demographics

All patients who sustained an isolated thoracic stab wound over the defined 40-month period were identified for review. Standard demographic data was recorded for each patient. (Table 2). The clinical management of each patient was reviewed and the clinical outcome of each patient documented. Patients with multiple injuries, gunshot wounds, impalement injuries or those who required operative intervention including video-assisted thoracoscopy have been excluded.

Costing

Using 45 index cases, a bottom-up micro-costing technique was used to estimate average expenses for our three defined management algorithms. Eight cost drivers were identified: in-patient stay, operative costs (including total time and surgical supplies calculated on an hourly rate), laboratory and radiological investigations, ward adjuncts, blood transfusion and blood product use, antimicrobial use and requirements for analgesia. The cost drivers and corresponding costs are listed in Table 3. The costs were based on discussion with individual finance officers and consultation with private health insurers. All costs pertain to previously published data from our institution.^{17–19} Costs include all overhead expenses such as water and electricity but do not include staff salaries. All expenses have been rounded up to the nearest ten. We have not been able to include the cost of vital services provided by our allied health professionals such as physiotherapists, dieticians and occupational therapists, making our calculations a conservative estimate of the true total.

Results

Over the 40-month period under review, 589 patients sustained an isolated thoracic stab wound. Eighty percent (472 patients) were treated nonoperatively and are considered for analysis. Of this nonoperative cohort, 79% (372 patients) required drainage of a pleural collection with a tube thoracostomy.

Active observation

Twenty-one per cent (100 patients) required admission for a period of active observation, of whom 80 patients (17%) had no identifiable injury and 20 (4%) had a small pneumothorax (less than 2 cm), which was observed for clinical deterioration or an increase in size. Table 2 demonstrates that these patients had normal oxygen saturation, respiratory and heart rates. The cohort's average lactate was also within normal limits at 2.2 mmol/l. All patients had a Glasgow Coma Score of 15. There was a 100% survival rate and no patient required admission to intensive care. No significant complications were recorded.

Management with tube thoracostomy

Twenty per cent (96 cases) had an isolated pneumothorax greater than 2 cm, which was drained with a tube thoracostomy. Again, these patients seem to present with normal oxygen saturation, respiratory and heart rates. Only 2% required admission to a high-dependency unit; all patients

survived and 84 cases (88%) had no recorded complications. Five patients (5%) had a small residual pneumothorax following removal of their tube. These were all observed. In three cases (3%) the tube was dislodged or fell out prematurely and required reinsertion. Other complications occurred in four patients (4%) and included

Table 2 Isolated thoracic stab wound cases; nonoperative management in cohort of 472 patients.

Management algorithm	Active observation		Nonoperative management	
	No visceral injury	Pneumothorax < 2 cm	Pneumothorax > 2 cm	Haemothorax
Cohort <i>n</i> (%)	80 (17)	20 (4)	96 (20)	276 (59)
Age, years (range)	28 (6–58)	26 (16–41)	27 (15–57)	27 (11–66)
Sex	7 F : 73 M	1 F : 19 M	8 F : 88 M	16 F : 260 M
Mean admission:				
Saturation, % (range)	97 (93–100)	98 (92–100)	97 (88–100)	95 (53–100)
Respiratory rate, breaths per minute (range)	17 (6–32)	19 (14–40)	19 (14–42)	20 (12–48)
Pulse, beats per minute (range)	84 (50–126)	81 (54–111)	86 (52–134)	86 (37–132)
Glasgow Coma Score (range)	7.39	7.37	7.35	7.35
pH (range)	7.39 (7.16–7.59)	7.37 (7.36–7.41)	7.35 (7.04–7.54)	7.35 (7.18–7.56)
Lactate, mmol/l (range)	2.1 (0.4–9.5)	2.3 (1.1–3.6)	2.3 (0.5–5.0)	2.8 (0.3–11.5)
Requiring ICU (%)	0	0	0	0
Requiring HDU (%)	0	0	2	0.5
Injury severity score (range)	2 (1–9)	3 (1–9)	6 (1–25)	7 (1–20)
Survival rate (%)	100	100	100	100
Weapon (<i>n</i>):				
Knife	53	15	73	208
Bush-knife	1	0	2	5
Bottle	6	1	1	1
Screwdriver	5	0	6	9
Spear	0	0	0	3
Other	1	1	1	2
Unknown	14	3	13	48

HDU, high-dependency unit; ICU, intensive care unit.

bleeding from the thoracostomy site, resolving surgical emphysema, development of a lower respiratory tract infection and a larger residual pneumothorax.

Fifty-nine per cent (276 cases) had an element of haemothorax. Admission lactate values were higher than other categories and were associated with the highest average injury severity score of all categories. The patients generally had subtle decreases in their admission oxygen saturation values and increased respiratory and heart rates. Less than 1% required high-care input and all patients survived. Sixty-eight percent (187 cases) had no recorded complications. Thirteen percent (36 cases) had a retained collection (pneumo- or haemothorax) of which 28 were small and therefore managed conservatively, 7 required a second thoracostomy and 1 was considered for early scheduled video-assisted thoracoscopy. Five percent (14 cases) were treated for sepsis, including lower respiratory tract infections, pleural empyema and wound infections. Three percent (8 cases) had other non-life threatening complications and, unfortunately, 11% of cases had nothing recorded (Table 4).

Management algorithm expense

Micro-costing of 45 index cases has been used in our cost estimations. This reveals that active observation on average costs 4,370 ZAR (£270). Average active observation costs are deduced from combining cost for those cases with no evidence of underlying visceral injury and those cases with an isolated small (less than 2 cm) pneumothorax. Nonoperative management costs have been subdivided into those with an isolated pneumothorax greater than 2 cm and those with haemothorax. An isolated pneumothorax requiring tube thoracostomy management costs 6,630 ZAR (£400). Haemothorax, which are more common and more difficult to treat, are associated with increased expense and estimations reveal an average cost of 21,850 ZAR (£1,310).

Cost analysis

Over the 40-month study period, Pietermaritzburg Metropolitan Trauma Service spent 7,235,980 ZAR (£441,400) on the nonoperative management of PTT. Six percent of the overall cost was spent on active observation, 10% of the

Table 3 Cost drivers.^{17–19,25}

Cost driver	Cost ^{a,b}	
	(ZAR)	(£)
Operative:		
Time (per minute)	110	7
Supplies and sundries (per hour)	230	14
Analgesia (per day)	50	3
Antimicrobials (per day):		
Co-amoxiclav	100	6
Piperacillin/tazobactam	650	40
Gentamicin	60	4
Fluconazole	750	46
Laboratory Investigations (per test):		
Full blood count	50	3
Urea and electrolytes	70	4
Coagulation	260	16
Calcium, magnesium, phosphate	80	5
Liver function test	160	10
Blood gas analysis	50	3
Urine dip/microscopy, culture and sensitivity	50	3
Ward adjuncts (per single item):		
Urinary catheter	40	2
Nasogastric tube	1	0.1
Central venous catheter	280	17
Peripheral intravenous cannula	30	2
Intercostal drain	150	9
Radiological investigations:		
Chest	250	15
Abdomen	270	16
CT Thorax	2,140	130
CT Abdomen	2,120	129
CT Angiogram	6,280	382
Pan CT (head, C-spine, thorax, abdomen, pelvis)	10,410	634
Inpatient stay (per day):		
Ward hospital bed	1,250	76
High care bed (ITU or HDU)	8,000	487
Blood and blood products:		
Unit packed RBC or use of cell save machine	1,850	113

^a Currency conversion rates as at 22 February 2017.
^b Figures rounded up to nearest 10.
CT, computed tomography; HDU, high dependency unit; ITU, intensive care unit.

Table 4 Complications from nonoperative management of haemothorax.

Complications	Cases	
	(n)	(%)
None	187	68
Retained collection	36	13
Nothing recorded	31	11
Sepsis	14	5
Other	8	3

total on isolated pneumothorax greater than 2 cm with tube thoracostomy and 84% of total costs were for tube thoracostomy drainage of haemothorax.

With our current algorithm, radiological investigations comprise on average 11% of the overall cost. Length of stay represents the largest proportion of cost for each algorithm at 72%, 75% and 82% for active observation, isolated pneumothorax and haemothorax, respectively (Table 5) Should the NICE guidance of obtaining a TCT in all cases with suspected chest injury be implemented across Pietermaritzburg Metropolitan Trauma Service, the region would need to spend an extra 2,140 ZAR (£130) for each case. This amounts to an extra 303,030 ZAR (£18,490) per annum and 1,515,120 ZAR (£92,430) over the next five years. Each algorithm for nonoperative management of PTT would understandably increase substantially. The percentage of the total cost spent on radiology for each algorithm would increase from an average 11% to 97%.

Discussion

Our data suggest that a selective approach to managing patients with PTT is both safe and cost effective. Adhering to our previously published criteria (Table 1), 80% of all isolated thoracic stab wounds were successfully managed non-operatively with no mortality and acceptable morbidity.⁸ Complication rates increased as the severity of pathology increased and are highest in patients with haemothorax.

TCT for each patient with chest trauma at the time of presentation, as recommended by NICE, is not routine in our setting and using the NICE guidelines would add an estimated average annual expense of 303,030 ZAR (£18,490) per annum. Additionally, it would expose numerous patients to unnecessary radiation. TCT is useful in a select cohort of patients, where the clinical picture progresses, deviates from the expected or usual clinical course and for patients with transmediastinal injuries. However, our data confirm that our algorithms based on clinical examination and basic radiographs can reliably and safely stratify patients.

Table 5 Estimated average overall costs for management algorithms used in penetrating thoracic stab wounds.²⁵

Management algorithm	Active observation		Pneumothorax > 2 cm (n = 96)		Haemothorax (n = 276)	
	Cost (ZAR) ^a	Percentage of total cost	Cost (ZAR) ^a	Percentage of total cost	Cost (ZAR) ^a	Percentage of total cost
n=276						
Operative	0	0	0	0	0	0
Analgesia	475	11	540	8	740	3
Antimicrobials	0	0	40	1	200	1
Laboratory investigations	185	4	180	3	320	2
Ward adjuncts	40	1	200	3	350	2
Radiological investigations	540	12	670	10	2,240	10
Inpatient stay	3,125	72	5,000	75	18,000	82
Blood and blood products	0	0	0	0	0	0
Total	4,370 ^b		6,630 ^c		21,850 ^d	

^a Figures rounded up to nearest 10; Currency conversion rates as at 17 April 2017.
^b £270.
^c £400.
^d £1,310.

In the UK, penetrating thoracic injury is most often as a result of stab wounds.⁵ Trauma care in the UK was described as 'less than good practice' for 60% of trauma patients prior to the introduction of the major trauma centre network.²¹ The introduction of the UK's major trauma network has shown excellent improvements in trauma care. There remain inconsistencies among these centres, but the national standardisation of management strategies has resulted in an 85% reduction in protocol variance.²² Following this nationwide reorganisation, Mhandu *et al.*²³ reported on the trends in cardiothoracic trauma during a single year in a London major trauma centre. Fifty-seven per cent (145 cases) of their cohort sustained PTT, predominantly knife wounds.²⁵ Pallett *et al.*²⁴ found that the introduction of a standard operating procedure in a London major trauma centre contributed to a reduction of inappropriate CT. This demonstrates the importance of defined management algorithms and their ability to reduce unnecessary radiation exposure.²⁴ While it is difficult to directly extrapolate clinical findings across vastly different healthcare systems, the South African data suggest that routine TCT in our setting is both avoidable and costly.

Conclusion

Our policy of selective management for PTT is safe and effective. For isolated thoracic stab wounds rigorous and serial clinical assessment with basic radiographs and adherence to stringent criteria can appropriately select patients amenable to nonoperative management and should not be disregarded. Across the Pietermaritzburg Metropolitan Trauma Service, TCT will continue to be reserved for selected patients who are identifiable from clinical examination and basic radiology.

It is clear that thoracic trauma in our setting even when managed under rigorous economic circumstances still incurs substantial expenses. Orchestrated government lead public health measures must be implemented to lessen overall levels of interpersonal violence in order that morbidity, mortality and financial repercussions of these injuries are reduced. Reducing overall incidence rates in our setting is likely the only sustainable way to substantially further reduce healthcare- and society-related costs.

References

1. National Audit Office. *Major Trauma Care in England. Report by the Comptroller and Auditor General, HC 213 Session 2009–2010*. London: Stationery Office; 2010.
2. Al-Koudmani I, Darwish B, Al-Kateb K, Taifour Y. Chest trauma experience over eleven-year period at Al-Mouassat University Teaching Hospital Damascus: a retrospective review of 888 cases. *J Cardiothorac Surg* 2012; **7**: 35.
3. Hardcastle TC, Oosthuizen G, Clarke D, Lutge E. Trauma, a preventable burden of disease in South Africa: review of the evidence, with a focus on KwaZulu-Natal. *S Afr Health Rev* 2016; **15**: 179–189.
4. Van Waes OJF, Halm JA, Van Imhoff DI *et al*. Selective non operative management of penetrating thoracic injury. *Eur J Emerg Med* 2018; **25**(1): 32–38.
5. Mohamed T, Chowdhry F, Rathinam S. Penetrating injuries of the chest. *Cardiothorac Surg* 2017; **35**(5): 255–261.
6. Arunan Y, Roodenburg B. Chest trauma. *Anaesth Intens Care Med* 2017; **1**: 1–5.
7. Moodley N, Aldous C, Clarke D. Current trauma patterns in Pietermaritzburg. *S Afr J Surg* 2015; **53**(3): 2–4.
8. Kong VY, Sartorius B, Clarke DL. The selective conservative management of penetrating thoracic trauma is still appropriate in the current era. *Injury* 2015; **46**: 49–53.
9. Mollberg NM, Wise SR, D Hoyos AL *et al*. Chest computed tomography for penetrating thoracic trauma after normal screening chest roentgenogram. *Ann Thorac Surg* 2012; **93**: 1,830–1,835.
10. Strumwasser A, Chong V, Chu E, Victorina GP. Thoracic computed tomography is an effective screening modality in patients with penetrating injuries to the chest. *Injury* 2016; **47**: 2000–2005.

11. National Institute for Health and Care Excellence. *Major Trauma: Assessment and Initial Management*. NICE Guideline NG39. London: NICE: 2016.
12. Davies RM, Scrimshire AB, Sweetman L *et al*. A decision tool for whole-body CT in major trauma that safely reduces unnecessary scanning and associated radiation risks: an initial exploratory analysis. *Injury* 2016; **47**: 43–49.
13. Hirshberg A, Thomson SR, Huizinga WKJ. Reliability of physical examination in penetrating chest injuries. *Injury* 1988; **19**: 407–409.
14. Hegarty MM. A conservative approach to penetrating injuries of the chest; experience with 131 successive cases. *Injury* 1976; **8**: 53–59.
15. Sandrasagra FA. Management of penetrating stab wounds of the chest: an assessment of the indications for early operation. *Thorax* 1978; **33**: 474–478.
16. Clarke DL, Quazi MA, Reddy K, Thomson SR. Emergency operation for penetrating thoracic trauma in a metropolitan surgical service in South Africa. *J Thorac Cardiovasc Surg* 2011; **42(3)**: 563–568.
17. Kong VY, Aldous C, Handley J, Clarke D. The cost effectiveness of early management of acute appendicitis underlies the importance of curative surgical service to a primary health care programme. *Ann R Coll Surg Engl* 2013; **95**: 280–284.
18. Parkinson F, Kent SWJ, Aldous C *et al*. The hospital cost of road traffic accidents at a South African regional trauma centre: a micro-costing study. *Injury* 2014; **45**: 342–345.
19. Dayananda KSS, Kong VY, Bruce JL *et al*. Selective non-operative management of abdominal stab wounds is a safe and cost effective strategy: a South African experience. *Ann R Coll Surg Engl* 2017; **99(6)**: 490–496.
20. Clement FM, Ghali WA, Donaldson C, Manns BJ. The impact of using different costing methods on the results of an economic evaluation of cardiac care: micro-costing vs gross-costing approaches. *Health Econ* 2009; **18**: 377–388.
21. Beattie R, Mhandu PCE, McManus K. Penetrating thoracic trauma. *Cardiothorac Surg* 2014; **32(5)**: 250–225.
22. McCullough AL, Haycock JC, Forward DP, Moran CG. Major trauma networks in England. *Br J Anaesth* 2014; **113(2)**: 202–206.
23. Mhandu P, Chaubby S, Robb D *et al*. Trends of cardiothoracic trauma at new trauma centre. *J Cardiothorac Surg* 2013; **8(Suppl 1)**: O74. DOI: 10.1186/1749-8090-8-S1-O74.
24. Pallett JR, Olding J, Hurst T *et al*. Have patient pathways for penetrating chest injuries improved since designation as a London major trauma centre? *Scand J Trauma Resusc Emerg Med* 2013; **21(Suppl 1)**: S21. DOI.org/10.1186/1757-7241-21-S1-S21.