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# The impact of a chest tube management protocol on the outcome of trauma patients with tube thoracostomy

## *Impacto de um protocolo de cuidados a pacientes com trauma torácico drenado*

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A B S T R A C T

**Objective:** to investigate the effect of standardized interventions in the management of tube thoracostomy patients and to assess the independent effect of each intervention. **Methods:** A chest tube management protocol was assessed in a retrospective cohort study. The tube thoracostomy protocol (TTP) was implemented in August 2012, and consisted of: antimicrobial prophylaxis, chest tube insertion in the operating room (OR), admission post chest tube thoracostomy (CTT) in a hospital floor separate from the emergency department (ED), and daily respiratory therapy (RT) sessions post-CTT. The inclusion criteria were, hemodynamic stability, patients between the ages of 15 and 59 years, and injury severity score (ISS) < 17. All patients had isolated injuries to the chest wall, lung, and pleura. During the study period 92 patients were managed according to the standardized protocol. The outcomes of those patients were compared to 99 patients treated before the TTP. Multivariate logistic regression analysis was performed to assess the independent effect of each variable of the protocol on selected outcomes. **Results:** Demographics, injury severity, and trauma mechanisms were similar among the groups. As expected, protocol compliance increased after the implementation of the TTP. There was a significant reduction ($p$<0.05) in the incidence of retained hemothoraces, empyemas, pneumonias, surgical site infections, post-procedural complications, hospital length of stay, and number of chest tube days. Respiratory therapy was independently linked to significant reduction ($p$<0.05) in the incidence of seven out of eight undesired outcomes after CTT. Antimicrobial prophylaxis was linked to a significant decrease ($p$<0.05) in retained hemothoraces, despite no significant ($p$<0.10) reductions in empyema and surgical site infections. Conversely, OR chest tube insertion was associated with significant ($p$<0.05) reduction of both complications, and also significantly decreased the incidence of pneumonias. **Conclusion:** Implementation of a TTP effectively reduced complications after CTT in trauma patients.

**Key words:** Traumatology. Thoracic Injuries. Physical Therapy Specialty. Empyema, Pleural. Thoracostomy.

## INTRODUCTION

Trauma has a staggering effect in society given that this disease afflicts patients during their most productive years. The World Heath Organization considers trauma a disease of the XXI century.[1] Trauma patients have prolonged hospital length of stay (LOS) and survivors frequently sustain incapacitating injuries. Traumatic injuries are the third most common cause of death in Brazil, adding up to 150,000 deaths a year, and three times as many permanently disabled patients.[2]

It is estimated that in 2011 more than 112,000 patients between the ages of 15 and 59 years-old died from external causes in Brazil. Making trauma, the most common cause of death among patients between 5 and 39 year-old since 1980. Moreover, it is known that trauma is one of the most important causes of potential years of life lost by premature death; three times greater than cardiovascular disease.[1,3] Hence it is extremely important to implement management changes that could reduce morbidity and mortality in trauma patients. Quality improvement strategies to enhance trauma care through best practice guidelines are important tools towards that goal. Those strategies originate from retrospective data analysis and provide risk adjusted information that allows hospitals to evaluate their performance relative to other centers. Thus, contributing to improvement in patient care.[1,4,5] Trauma registries are also important source of data that can be used to improve the quality of care of injured patients. Moreover, those registries provide information for scientific research and resource management in trauma centers.[5] This is particularly important in injuries associated with high mortality rates.

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Thoracic injuries are responsible for approximately 20 to 25% of all trauma deaths. Those injuries are also linked to high complication rates. The incidence of empyema in patients with thoracic trauma can be as high as 27%.[6,7,8] The majority of those cases are associated with chest tube thoracostomy (CTT). Moreover, the complication rate in thoracic trauma is also determined by injuries remote from the chest. Our group recently showed that the incidence of empyema was 19% higher in patients who underwent trauma laparotomy in conjunction with CTT, compared to patients who underwent CTT alone.[9]

The present study was designed to investigate the effect of standardized interventions in the management of tube thoracostomy patients and to assess the independent effect of each intervention.

## METHODS

The impact of the tube thoracostomy protocol (TTP) was assessed in a retrospective cohort study from January 1, 2011 to December 31, 2013. Data for the study was obtained from the hospital's trauma registry (Collector®). This study was approved by the research ethics committee of the "Hospital Risoleta Tolentino Neves" (protocol 3/201) and by the research ethics committee of the Universidade Federal Minas Gerais (UFMG), Brazil (CAAE 39504714.3.0000.5149). It was carried out at a 360-bed public/academic high volume trauma center affiliated with the UFMG.

The TTP began in August 2012 wherein all patients were triaged according to the Manchester[10] triage system and were initially assessed in the ER. Once the need for CTT was confirmed, patients were taken to the operating room for the procedure. Contrarily, chest tube insertion in the ER was the norm before the implementation of the TTP. The protocol also called for antimicrobial prophylaxis (cefazolin 1g) immediately before chest tube insertion. Chest tube was inserted in order to comply with the Advanced Trauma Life Support (ATLS®) guidelines. Transfer of patients who underwent CTT to a hospital floor or to the intensive care unit was considered a priority in the TTP. In contrast, before the protocol, CTT patients frequently waited for long periods in the ED before being transferred to a hospital floor bed. Patients managed according to the protocol received at least two sessions of respiratory therapy a day. In contrast, that intervention was infrequent before the implementation of the protocol. All CTT patients were seen in follow up visits within 30 days of the hospital discharge date.

Patients were distributed between two groups (A1 and A2). Group A1 comprised chest trauma patients treated before the implementation of the TTP. Group A2 patients were managed according to the TTP. Thoracic traumas were both blunt and penetrating. The latter included gunshot mechanism and stab wounds.

The inclusion criteria were hemodynamically stable trauma patients (systolic arterial pressure e" 90mmHg), between the ages of 15 and 59 years who underwent CTT within the first 24h after injury. The injury severity scores (ISS) were < 16, the revised trauma scores (RTS) were > 6, and the trauma and injury severity score (TRISS) > 0.99. Chest tube insertion was in keeping with the Advanced Trauma Life Support (ATLS®) guidelines.

Patients with co-morbidities (diabetes, chronic renal failure, chronic liver failure) and those who underwent a surgical procedure within 24 hours preceding or following the first CTT were excluded from the study. Any patient who received antibiotic prophylaxis for reasons other than CTT was also excluded.

Statistical analysis was performed with univariate analysis of the medians of continuous variables in the two groups was performed using the non-parametric Mann Whitney test. Categorical variables were analyzed with the Chi-Square test or Fisher's exact. Results are reported as proportions, medians and interquartile range. Multivariate logistic binary regression analysis was performed to determine the independent effect of each protocol variable on the outcome. Lastly, the phenomenon of complete separation was also addressed in the statistical analysis[11]. An estimated model was produced for each outcome by the inclusion of all the items of the protocol obtaining adjusted odds ratios with confidence interval of 95% (IC 95%), and $p$ values < 0.05 were considered statistically significant. Whereas, $p$ values < 0.10 or > 0.05 were described as a trend towards significance[12].

## RESULTS

A total of 191 patients were included in the study, 92 were managed in accordance with the TTP (Group A2), whereas 99 patients were treated before the implementation of the protocol (Group A1). A total of 305 patients did not meet the inclusion criteria, thus were excluded from the study. There were no statistically significant differences between groups A1 and A2 with respect to demographic data, ISS, and trauma mechanisms (Table 1).

Implementation of the protocol was successful as shown by the increase of all components of the protocol in group A2 compared to group A1 (Table 2); respectively (respiratory therapy 96.7% vs. 1%), operating room chest tube insertion (75% vs. 59.6%), usage of prophylactic antimicrobial (54.3% vs. 31.3%). Moreover, there was a significant decrease in the number of patients who spent more than 24 hours in the ED in group A2 compared to group A1 (16.3% vs. 43.4%).

Furthermore, 45% of the patients in group A2 were managed according to at least four of the five protocol components. Only 18.7% of the patients were managed with 2 or less components of the protocol. (Table 3)

The only outcome that did not show a statistically significant improvement with the implementation of the TTP (group A2) was the need for a new surgical procedure, i.e, thoracotomy, thoracoscopy, and insertion of a new or an additional chest tube (Table 4). Furthermore, the median hospital length of stay and the number of chest tube days (median) also reduced significantly in group A2 compared to group A1.

The independent effects of each component of the protocol on selected outcomes are shown in table 5. The need for a new surgical procedure was not associated with any protocol component. However, results demonstrated an unequivocal effect of respiratory therapy twice a day (group A2) in the improvement of the selected outcomes. As shown by a 79% decrease in retained hemothoraces in group A2 compared to group A1 (OR=0.21; $p < 0.01$). Insertion of the chest tube in the operating room resulted in a statistically significant decrease in the incidence of empyemas (OR=0.33), pneumonias (OR=18), and surgical site infections (OR=0.17). Interestingly, prophylactic antimicrobials showed only a trend in reducing the rates of empyemas and surgical site infections ($p < 0.10$) after chest tube insertion.

## DISCUSSION

Our findings showed that the protocol described herein resulted in significant improvement in the management of patients who underwent chest tube thoracostomy. This study also underscored the importance of the trauma registry. Given that the data obtained from the registry served, not only, to demonstrated the problem but also provided means to develop the protocol and to verify the results[4].

Our study showed that the components of the protocol could be implemented in a high volume trauma center of a public health system. The results demonstrated that the protocol led to a reduction in the incidence of several complications frequently seen in patients who undergo CTT for trauma. Most importantly, retained hemothoraces, empyema, pneumonia and surgical site infection. Furthermore, the protocol also led to other improvements in patient care, such as, decrease hospital LOS, decrease in the number of chest tube days, and a reduction in complications detected during follow-up visits. For the most part, the aforementioned findings could help improve patient flow within the hospital and resource

**Table 1 –** Gender, age, *Injury Severity Score*, trauma mechanisms. Total, Group A1, Group A2.

| | Total (n=191; 100%) | Group A1 (n=99; 100%) | Group A2 (n=92; 100%) | p |
|---|---|---|---|---|
| Gender Male (n;%) | 179 (93.7%) | 93 (94.0%) | 86 (93.5%) | 0.896 |
| Age (median; IIQ) | 28 (21; 38) | 28 (21; 37) | 28 (21; 39) | 0.508 |
| ISS (median; IIQ) | 9 (9; 9) | 9 (9; 10) | 9 (9; 9) | 0.594 |
| Trauma mechanism (n;%) | | | | |
| — Gunshot wound | 89 (46.6%) | 52 (52.5%) | 37 (40.2%) | 0.214 |
| — Stab wound | 63 (33.0%) | 28 (28.3%) | 35 (38.0%) | |
| — Blunt | 39 (20.4%) | 19 (19.2%) | 20 (21.7%) | |

*Source: Hospital Risoleta Tolentino Neves, MG (2011 – 2013).*
*Note: IIQ: Interquartile range; Chi square; Mann-Whitney test (significance set at* p<*0.05)*

**Table 2 –** Hospital admission site, respiratory therapy, operating room chest tube insertion, prophylactic antimicrobial. Total, Group A1, Group A2.

| | Total (n=191; 100%) | Group A1 (n=99; 100%) | Group A2 (n=92; 100%) | p |
|---|---|---|---|---|
| Hospital admission site (n;%) | | | | |
| — ICU | 7 (0.4%) | 5 (5.1%) | 2 (2.2%) | 0.447 |
| — Floor bed | 184 (96.3%) | 95 (96.0%) | 89 (97.0%) | 0.999 |
| — Emergency Department >24h. | 58 (30.4%) | 43 (43.4%) | 15 (16.3%) | <0.001 |
| Respiratory therapy 2x day (n;%) | 90 (47.1%) | 1 (1.0%) | 89 (96.7%) | <0.001 |
| OR chest tube insertion (n;%) | 128 (67.0%) | 59 (59.6%) | 69 (75.0%) | 0.032 |
| Prophylactic antimicrobial (n;%) | 81 (42.4%) | 31 (31.3%) | 50 (54.3%) | 0.001 |

*Source: Hospital Risoleta Tolentino Neves, MG (2011 – 2013).*
*Chi square and Fisher's exact test*

**Table 3 –** Compliance to protocol in Group A2.

| Number of protocol components | n (%) |
|---|---|
| One | 1 (1/92=1.1%) |
| Two | 17 (17/92=18.7%) |
| Three | 32 (32/92=34.7%) |
| Four ou Five | 41 (41/92=44.5%) |

*Source: Hospital Risoleta Tolentino Neves, MG (2011 – 2013).*

**Table 4 –** Intra-thoracic complications, surgical site infection, need for new operation, patients with complications detected in follow-up, hospital length of stay, chest tube length of stay. Group A1, Group A2.

| | Group A1 (n=99; 100%) | Group A2 (n=92; 100%) | p |
|---|---|---|---|
| Intra-thoracic complications (n;%) | | | |
| — Retained hemothorax | 31 (31.3%) | 6 (6.5%) | <0.001 |
| — Empyema | 22 (22.2%) | 2 (2.0%) | <0.001 |
| — Pneumonia | 11 (11.1%) | 0 (0.0%) | <0.001 |
| Surgical site infections (n;%) | 10 (10.1%) | 0 (0.0%) | 0.002 |
| New surgical procedure (n;%) | 13 (13.1%) | 9 (9.8%) | 0.469 |
| Complications detected in follow-up (n;%) | 12 (12.1%) | 3 (3.3%) | <0.001 |
| Hospital length of stay (median; IIQ) | 5 (7; 11) | 4 (5; 8) | <0.001 |
| Chest tube length of stay (median; IIQ) | 4 (5; 7) | 3 (4; 5) | <0.001 |

*Source: Hospital Risoleta Tolentino Neves, MG (2011 – 2013).*
*Chi-square, Fisher's exact test, Man-Whitney test; new surgical procedure: thoracotomy, thoracoscopy, and insertion of a new or an additional chest tube.*

**Table 5 –** Odds Ratio, Intra-thoracic complications, surgical site infection, patients with complications detected in follow-up, hospital length of stay, chest tube length of stay; multivariate analysis.

| | Selected Outcomes OR (IC95%) | | | | | | |
|---|---|---|---|---|---|---|---|
| Protocol variables linked to any selected outcome | Retained hemothorax | Empyema | Pneumonia | Surgical site infection | Complication detected in follow-up | Hospital LOS<6 days | Chest tube LOS<5 days |
| — Resp. Therapy | 0.21*** (0.08-0.54) | 0.11*** (0.03-0.44) | 0.05** (0.03-0.90) | 0.04** (0.002-0.73) | 0.33*** (0.16-0.69) | 0.46** (0.25-0.85) | 0.26**** (0.14-0.48) |
| — Hospital admission site diferente from ED | 1.23 (0.52-2.91) | 0.52 (0.18-1.47) | 0.55 (0.14-2.15) | 0.22* (0.05-1.01) | 1.11 (0.51-2.41) | 1.95* (0.90-4.20) | 1.27 (0.60-2.70) |
| — Chest tube insertion in the operating room | 0.88 (0.37-2.06) | 0.33** (0.12-0.91) | 0.18** (0.04-0.75) | 0.17** (0.04-0.72) | 0.72 (0.34-1.53) | 0.91 (0.44-1.89) | 0.78 (0.38-1.60) |
| — Prophylactic antimicrobials | 0.40** (0.17-0.94) | 0.40* (0.14-1.14) | 0.65 (0.17-2.49) | 0.19* (0.03-1.16) | 0.62 (0.31-1.25) | 1.34 (0.72-2.49) | 1.12 (0.60-2.10) |

*Source: Hospital Risoleta Tolentino Neves, MG (2011 – 2013).*
**p<0.10;** p<0.05; *** p<0.01; **** p<0.001. LOS (length of stay), ED (emergency department). Statistical significance set at p<0.05.*

management in high volume trauma centers[13]. For instance, it became clear, after the beginning of the study that two additional respiratory therapists were needed to provide adequate care for CTT patients.

The implementation of the protocol involved the work of several health care professionals. Firstly, the institution's chief of trauma/acute care surgery had to endorse the plan and promote it amongst the staff surgeons,

residents, and interns. The trauma nurse coordinator was the cornerstone of the project, providing supervision to prevent protocol drift, maintaining protocol compliance, and collecting data. Secondly, the nursing staff of all hospital sectors involved with patient care, and the respiratory therapy team had to coordinate the execution of the protocol. An example of that coordination was the fact that daily respiratory therapy was practically inexistent before the implementation of the protocol, increasing from 1% to 97%. Previous studies have shown the importance of the respiratory therapist professional in the rehabilitation of chest trauma patients, particularly those who undergo CTT[14-18].

A major finding of the present study was that chest tube placement in the operating room was independently associated with a reduction in the incidence of major complications, such as empyema, pneumonia and surgical site infection compared to chest tube placement in the ED. Therefore, whenever possible, CTT should be performed in the operating room. Obviously, that is not the case in emergency situations.

Because chest tube placement is usually considered a minor procedure, keeping those patients in the ED was an acceptable practice in our institution.[19] However, our results showed that the disposition of CTT patients to appropriate hospital sectors could also contribute to reduce complications. Furthermore, despite the high volume of trauma in our institution, classifying CTT patients as priority facilitated the access of those patients to a floor bed. Thus, decreasing the time spent in the ED and reducing complications. In summary, we believe that the ED is an inappropriate setting for the management of CTT[20].

This study has several limitations. Most importantly, the lack of video-assisted thoracoscopy surgery (VATS) in our institution prevented us from assessing the role of this procedure. Video-assisted thoracoscopy surgery is considered a major tool in the treatment of patients who sustain traumatic chest injuries and their complications[20,21]. The lack of that tool in our institution could explain the absence of a significant difference in the need for a new surgical procedure between the groups. Moreover, we did not apply negative pressure to the underwater seal chest drainage systems. Therefore, the effect of that intervention was not investigated.

Another important limitation of the study was that before the implementation of the protocol (Group A1) only 1% of the patients underwent respiratory therapy. One should consider that low number when interpreting the similarities between the two groups. Nonetheless, our results showed that the demographic data, injury severity and trauma mechanisms were similar in the groups.

In our institution, the use of prophylactic antimicrobial in CTT was practiced prior to the beginning of the protocol. This could explain the lack of effect of that intervention on the reduction of empyemas and surgical site infections. However, compliance with that practice was only 31% in group A1. The implementation of the protocol resulted in a 20% increase in the use of prophylactic antimicrobial in CTT patients.

In summary, our findings showed that protocolized management of trauma patients who undergo CTT results in a significant reduction in chest complications. Moreover, the protocol described herein helped to improve patient flow and the management of resources in a high volume trauma center.

## R E S U M O

***Objetivo:*** *avaliar a implantação do Cuidado Padronizado com o Dreno de Tórax (CPDT) em um hospital público, referência para o trauma, e o impacto independente de cada um dos itens do protocolo no período do estudo sobre desfechos selecionados.* ***Métodos:*** *coorte retrospectiva avaliando implementação do Cuidado Padronizado para o Dreno de Tórax (CPDT). Foram incluídos pacientes entre 15 e 59 anos de idade, hemodinamicamente estáveis, com* Injury Severity Score *inferior a 17, com lesão isolada na parede do tórax, pulmão e pleura. Foram comparados 99 pacientes antes do CPDT com 92 depois do CPDT. Foi realizada comparação de desfechos selecionados por meio de diferença de proporções. A regressão logística multivariada foi feita para análise do efeito independente de cada variável do protocolo.* ***Resultados:*** *não houve diferença entre os grupos quanto às variáveis sociodemográficas, índice de gravidade e mecanismo de trauma. A implementação do CPDT resultou no aumento no percentual de todos os itens do protocolo. Houve redução significativa (p<0,05) de hemotórax retido, empiema, pneumonia, infecções de ferida operatória e nova operação, queda do percentual de pacientes retornados com complicações, tempo de internação e de permanência do dreno. A fisioterapia revelou-se independentemente associada à redução de sete dos oito desfechos (p<0,05). O antibiótico presuntivo revelou tendência de associação com a redução de empiema e de infecções de ferida operatória (p<0,10) e esteve associado à redução do hemotórax retido (p<0,05). A drenagem no centro cirúrgico esteve associada à redução de empiema, pneumonia e infecção de ferida operatória (p<0,05).* ***Conclusão****: a implementação do CPDT foi efetiva na redução de complicações de pacientes com dreno de tórax.*

***Descritores:*** *Traumatologia. Traumatismos torácicos. Fisioterapia. Empiema Pleural. Toracostomia.*

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