CHEST TUBE MANAGEMENT

SUMMARY

Tube thoracostomy, or chest tube (CT) placement, is often indicated for the treatment of pneumothorax, hemothorax, or pleural effusion following traumatic injury or thoracic surgery. Subsequent management of the CT must be individualized to the patient, taking into consideration the reason for CT placement, whether or not the patient has had pulmonary resection, and whether the patient is mechanically ventilated. Premature CT removal, as well as unnecessary delays in CT removal, leads to increased hospital stays and costs.

RECOMMENDATIONS

- **Level 1**
  - **CT drainage should be ≤ 2 ml/kg/day before removal.**
- **Level 2**
  - **CTs can be removed equally safely at end-inspiration or end-expiration.**
  - **CTs may be safely removed on suction.**
  - **A brief trial of waterseal prior to CT removal may allow occult air leaks to become clinically apparent and reduce the need for CT reinsertion due to recurrent pneumothorax. Such trials, however, will generally increase hospital length of stay and the number of chest radiographs (CXRs) obtained.**
  - **After pulmonary resection, small air leaks will resolve significantly more quickly if the CT is placed to waterseal**
  - **In the setting of penetrating trauma to the chest, a single dose of Ancef 2 gm IV should be administered prior to CT insertion.**
- **Level 3**
  - **In mechanically ventilated patients, a CXR obtained between one and three hours after removal of a CT is sufficient to identify a recurrent pneumothorax.**
  - **A daily CXR is not indicated to monitor CTs in the intensive care unit. Routine monitoring and patient care will identify the need for CXR based on clinical necessity.**

INTRODUCTION

Tube thoracostomy, or chest tube (CT) placement, is often indicated for the treatment of pneumothorax (PTX) and/or hemothorax (HTX). Although there is generally agreement among surgeons on the indications and technique for CT insertion, there is little consensus on the subsequent management of these tubes once placed. Management practices are often based on institution and physician-specific training and preferences developed from anecdotal experience. The ideal CT management algorithm has yet to be determined. Specifically, wide variation in management practices exists with regards to the timing and parameters under which CTs should be removed, the best method of removal, and the need for chest X-rays pre- and post-CT removal.

EVIDENCE DEFINITIONS

- **Class I:** Prospective randomized controlled trial.
- **Class II:** Prospective clinical study or retrospective analysis of reliable data. Includes observational, cohort, prevalence, or case control studies.
- **Class III:** Retrospective study. Includes database or registry reviews, large series of case reports, expert opinion.
- **Technology assessment:** A technology study which does not lend itself to classification in the above-mentioned format. Devices are evaluated in terms of their accuracy, reliability, therapeutic potential, or cost effectiveness.

LEVEL OF RECOMMENDATION DEFINITIONS

- **Level 1:** Convincingly justifiable based on available scientific information alone. Usually based on Class I data or strong Class II evidence if randomized testing is inappropriate. Conversely, low quality or contradictory Class I data may be insufficient to support a Level I recommendation.
- **Level 2:** Reasonably justifiable based on available scientific evidence and strongly supported by expert opinion. Usually supported by Class II data or a preponderance of Class III evidence.
- **Level 3:** Supported by available data, but scientific evidence is lacking. Generally supported by Class III data. Useful for educational purposes and in guiding future clinical research.

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LITERATURE REVIEW

What volume of CT drainage is appropriate to consider removal of the tube?

In 2002, Younes performed a prospective randomized study to evaluate the timing of CT removal in regards to the daily CT drainage volume (1). Specifically, the study compared removal when drainage was ≤ 100 ml/day, ≤ 150 ml/day or ≤ 200 ml/day. Fluid reaccumulation and the need for thoracentesis were evaluated. No major differences were noted between the groups, concluding that increasing the threshold of daily drainage to 200 ml before removing the CT could lead to quicker removal of the CT, reducing hospitalization time and overall cost. Davis defined drainage resolution as <2 ml/kg (2). Although the study did not specifically evaluate patients for the recurrence of pleural fluid, this parameter was not reported to adversely influence study outcomes.

Should CTs be removed at end-inspiration or end-expiration?

Bell designed a prospective, randomized study to evaluate whether a recurrent pneumothorax (PTX) was more likely with CT removal at end-inspiration or end-expiration (3). Of 102 CTs in 69 blunt and penetrating trauma patients, 50 were assigned to end-expiration removal vs. 52 to end-inspiration removal. The results showed an 8% rate of recurrent PTX in the end-inspiration group and 6% rate in the end-expiration group (p=1.0). No other factors were identified that predisposed to recurrent PTX. The study concluded that the risk of recurrent PTX was similar between both groups and that either method of CT removal was safe.

Should CTs be removed on waterseal or on suction?

In 1994, Davis published a randomized prospective study designed to determine the differences between removing CTs on suction vs. removal on waterseal (2). Eighty trauma patients were included, randomizing 40 patients to each arm. Patients on mechanical ventilation, post-thoracotomy patients and patients with multiple CTs were excluded. Patients were randomized to their respective study arms when the CT showed no evidence of an air leak and drainage was <2 ml/kg over 24 hours. Prior to CT removal, CTs in the waterseal group were taken off suction and chest radiographs (CXRs) were obtained at six and 24 hours to evaluate for recurrent PTX. If a recurrent PTX was seen, the patient was placed back on suction for 24 hours and the process repeated. If no recurrent PTX was appreciated, the CT was removed. In the suction group, CTs remained on suction for 24 hours after resolution of the air leak. No additional CXRs were obtained before removal. In both groups following CT removal, a CXR was obtained immediately and at 8-12 hours post-removal. Only two recurrent PTX were seen in the suction group and one in the waterseal group; only one patient in each group required replacement of a tube (2.5%). Patients in the waterseal group had CTs in place on average 20.3 hours longer than the suction group, and they required more CXRs to monitor their care. This study concluded that CT removal on suction was safe, and protocols using waterseal before removal led to a longer hospital length of stay and an increased number of CXRs.

Martino published a prospective, randomized study to determine whether CT removal on suction allowed for shorter CT duration than removal on waterseal (4). Two hundred and five trauma patients were included, with 93 patients (45%) in the waterseal group and 112 (55%) in the suction group. Patients on mechanical ventilation for >24 were excluded. Patients were randomized to their respective study arms when CT drainage was <150 mL/24 hrs and there was no significant PTX or air leak. Patients in the waterseal group had their tubes removed from suction and a CXR obtained 6-8 hours later. Four patients in the waterseal group developed a PTX and the CTs were placed back on suction and the process repeated. Patients in the suction group had their CT disconnected from suction, and the CT was pulled immediately. Following CT removal, a recurrent PTX was seen in 13 patients in the waterseal group, only one of which required replacement of the tube. In the suction group, 9 patients had recurrent PTX and 7 required replacement of a tube. This study concluded that the waterseal group was more likely to have a recurrent PTX after CT removal, but was less likely to need CT replacement. Additionally, the average number of CXRs in the waterseal group was 6.5 compared to 5.5 in suction group. Initially, there was no significant difference in CT duration or hospital length of stay (LOS). If CT replacement were required, however, hospital LOS was twice as long. The study concluded that a short trial of waterseal might allow occult air leaks to become clinically apparent and reduced the need for another CT.

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Two further studies were performed regarding the question of CT removal on suction vs. waterseal, specifically focusing on the management of patients after pulmonary resection. In 2001, Cerfolio performed a randomized, prospective trial to evaluate whether CTs should be placed on waterseal or suction after pulmonary surgery to stop air leaks (5). Additionally, this study established a classification method to characterize the air leak. Included were 140 consecutive patients undergoing elective pulmonary resection by a single surgeon. Excluded were patients undergoing exclusively Video Assisted Thorascopic Surgery (VATS), lung volume reduction surgery, pneumonectomy, or sleeve resection. On post-operative day (POD) #2, patients with air leaks were either placed in the pre-randomized suction vs. waterseal groups. There were 18 patients in the waterseal group and 15 patients in the suction group. In the waterseal group, 12 of the 18 patients (67%) had no further leak by POD #3. The remaining six who had a persistent leak had leaks that were characterized as ≥ 4/7 in size (per the Pleurovac leak meter). In the suction group, only 1 of the 15 had stopped the air leak by POD #3. The remaining 14 patients were then placed to waterseal. Of these 14 patients, 13 had no further air leaks by POD #4. The total number of patients ultimately placed on waterseal was 32 (18 + 14); 25 of these (78%) had air leaks that stopped and all were leaks that were characterized as ≤ 3/7 on the leak meter. Of these 25, 23 had leaks that stopped within 24 hours after being put on waterseal. Out of the 32 pts, seven had developed a PTX on waterseal. Six out of 7 had leaks characterized as ≥ 4/7 on the leak meter. This study came to the conclusion that placing CTs on waterseal seems to be superior to wall suction for stopping air leaks after pulmonary resection. However, waterseal does not stop leaks that are characterized as 4/7 or greater. A PTX may occur on waterseal with leaks this large. In 2002, Marshall performed a randomized, prospective study to evaluate suction vs. waterseal for the management of CTs after pulmonary resection (6). Sixty-eight consecutive patients undergoing wedge resection, segmentectomy, or lobectomy were randomized to waterseal or suction groups. After surgery, all patients had their CTs placed to -20 cm H_2O suction in the operating room to establish initial expansion of the lung, followed by removal from suction for transport to the post-anesthesia care unit (PACU). In the PACU, patients were randomized to the waterseal or suction group. If patients in the waterseal group had > 25% PTX upon arrival to the PACU, the CT would be put on -10cm H_2O suction until resolution of the PTX; then it was placed back on waterseal. The CT was removed when the air leak resolved and the drainage was <300 ml/24 hrs. Patients in the suction group were kept on suction until the air leak resolved, and then placed on waterseal. The tube was removed when the drainage was <300 ml/24 hrs. Of note, adjustments to the data were made taking into consideration the length of pulmonary staple lines for comparison. Study results showed that air leaks in the waterseal group lasted a mean of 1.5 days ± 0.3 days. Air leaks in the suction group lasted an average of 3.3 days ± 0.8 days (p=0.05). CTs in the waterseal group were in place an average of 3.3 days ± 0.4 days. CTs in the suction group were in place an average of 5.5 ± 1.0 days (p=0.06). This study concluded that the duration of air leaks in the waterseal group was approximately half of that observed in the suction group. The study surmised that the leak was kept open by the suction, and when placed on waterseal, the decreased volume of leaking air allowed lung parenchyma to heal more readily.

When should CXRs be obtained after removal of a CT?

In 2000, Pacanowski performed a retrospective review of 105 patients with 113 CTs to see if routine CXR after CT removal in traumatic hemopneumothorax (HPTX) offered any benefit over clinical evaluation of respiratory status (7). In this study, CTs were removed after a 24-hour period of waterseal and CT output was <100 ml/24 hrs. Prior to removal, a CXR was performed to confirm resolution of the HPTX. CTs were then removed at peak inspiration. Follow-up CXRs were obtained on average 8 and 22 hours after removal. Recurrent HPTX was considered a HPTX seen on post-removal films, but not on pre-removal film. Persistent HPTX was defined as a stable HPTX evident on pre-removal and post-removal films. Study results showed that the average duration of CT placement was 5 days. Twelve patients (11%) had recurrent PTX and one required replacement of the CT for reaccumulation of a hemothorax. Nine of the 12 recurrent HPTX were evident at time of the first post-removal CXR. All 12 recurrences were evident within 24 hours post CT removal. Three patients had "symptoms" (dyspnea, shortness of breath, or chest pain) after removal, but none had a PTX. This study concluded that after completing a trial of waterseal, clinical assessment of respiratory status was sufficient to identify recurrent HPTX requiring further intervention. However, being retrospective in nature, the authors advocated obtaining a single upright CXR 24 hours after CT removal to evaluate for recurrent HPTX. In 2002, Palesty came to a similar conclusion in a retrospective review that looked at 73 patients (8). Although the timing of post-removal CXRs varied, all had a CXR performed within 24 hours of removal in addition to the CXR performed prior to removal. Eight patients had post-removal CXRs that differed from the pre-removal film; of these, only two patients required replacement of a CT. Although a CXR had been obtained, the decision to replace the CT was primarily based on clinical findings, however. The study concluded that obtaining a CXR following CT removal should be based on sound clinical judgment and discrimination of the surgeon. These results were also in agreement with Pacharn, who performed a one-year, retrospective review of pediatric cardiac surgery patients to evaluate the benefit of CXRs following CT removal (9). The study concluded that in this population, clinical signs and symptoms identified nearly all patients with significant PTX, and that CXR should be reserved for select, high-risk groups and those with clinical signs and symptoms.

McCormick performed a retrospective review evaluating 703 postoperative cardiac patients who underwent routine CXR after CT removal, and 297 who received no imaging (10). In those who received a CXR, the incidence of intervention was 1.7%. In those who received no CXR, the incidence of intervention was 0.6% (p=0.25). The CXR prompted intervention in four patients who were asymptomatic. This raised the possibility that these patients may have done well without intervention, and that CXR may have had a deleterious effect on patient care. The study concluded that omission of routine CXRs following CT removal is safe, and that liberal use of clinical indications for imaging should be encouraged. Pizano prospectively evaluated the timing of post-CT removal patients in mechanically ventilated patients (11). Seventy-five patients on positive pressure ventilation were evaluated with CXRs obtained at one hour, 10 hours, and 36 hours post-removal. Nine of the 75 patients (12%) had a PTX following CT removal, all of which were seen on the first (one-hour) CXR. Only 2 of the 9 patients required replacement of the CT. The authors concluded that a CXR obtained within 3 hours after CT removal effectively identifies a PTX in mechanically ventilated patients.

Should a daily CXR be obtained when a patient has a CT?
Silverstein concluded in a 1993 prospective review of 525 routine morning intensive care unit CXRs that cardiopulmonary findings were noted on only 89 (12%) (12). Of these, only 3 cases required immediate action by the physician based solely on the CXR findings. The study also examined the use of CXRs to monitor medical devices such as CTs. Out of the 120 CTs seen on CXR, only three (2.5%) were in minor incorrect position (not requiring manipulation) and only 1 (0.8%) was in major incorrect position, requiring manipulation. His conclusions were that routine daily CXRs were unwarranted, particularly if the goal is to monitor position of a medical device such as a CT.

Should prophylactic antibiotics be used in the setting of trauma?
Sanabria et al. concluded in a meta-analysis study of 5 class I randomized controlled trials (614 patients) that use of prophylactic antibiotics is recommended in patients with isolated thoracic trauma requiring the use of tube thoracostomy to protect against subsequent development of empyema and pneumonia. They found significant reductions in the risk of empyema (relative risk [RR] 0.19, 95% CI, 0.07-0.5) and pneumonia (RR 0.44, 95% CI, 0.27-0.73) in patients who received antibiotic prophylaxis compared with placebo, in particular with penetrating injuries as opposed to blunt. Although they make this statement, the paper does not adequately stratify datasets between penetrating vs blunt etiologies. Overall, the averaged frequency of empyema decreased from 7.6% to 1.14%, and for pneumonia 16% to 7.6%. Antibiotics used during these studies were clindamycin, cefamandole, cefazolin, and cefonicid, the largest proportion utilizing cefazolin. This is reasonable, as S*taphylococcus. aureus* is the most frequently isolated organism in cases of posttraumatic empyema. They also showed that there is no significant difference in using antibiotics for 24 hours following chest tube insertion vs. more than 24 hours. The study emphasized that the most important factor in empyema prevention is adequate drainage of the pleural cavity (13).

Bosman et al. also produced a meta-analysis which included 11 randomized controlled trials, encompassing 1234 patients (14). In Bosman's paper, the stratification of penetrating vs. blunt trauma was more evident, as they showed that all patients who sustained penetrating trauma had nearly 3 times lower risk of empyema if they received prophylactic antibiotics as compared to those who did not (14 patients or 2.1% vs. 39 patients or 6.8% respectively, OR 0.32, [0.17, 0.61]). Conversely, those who had blunt trauma had no effect of antibiotic prophylaxis, reflecting other published literature (OR 1.30, [0.46, 3.67]).

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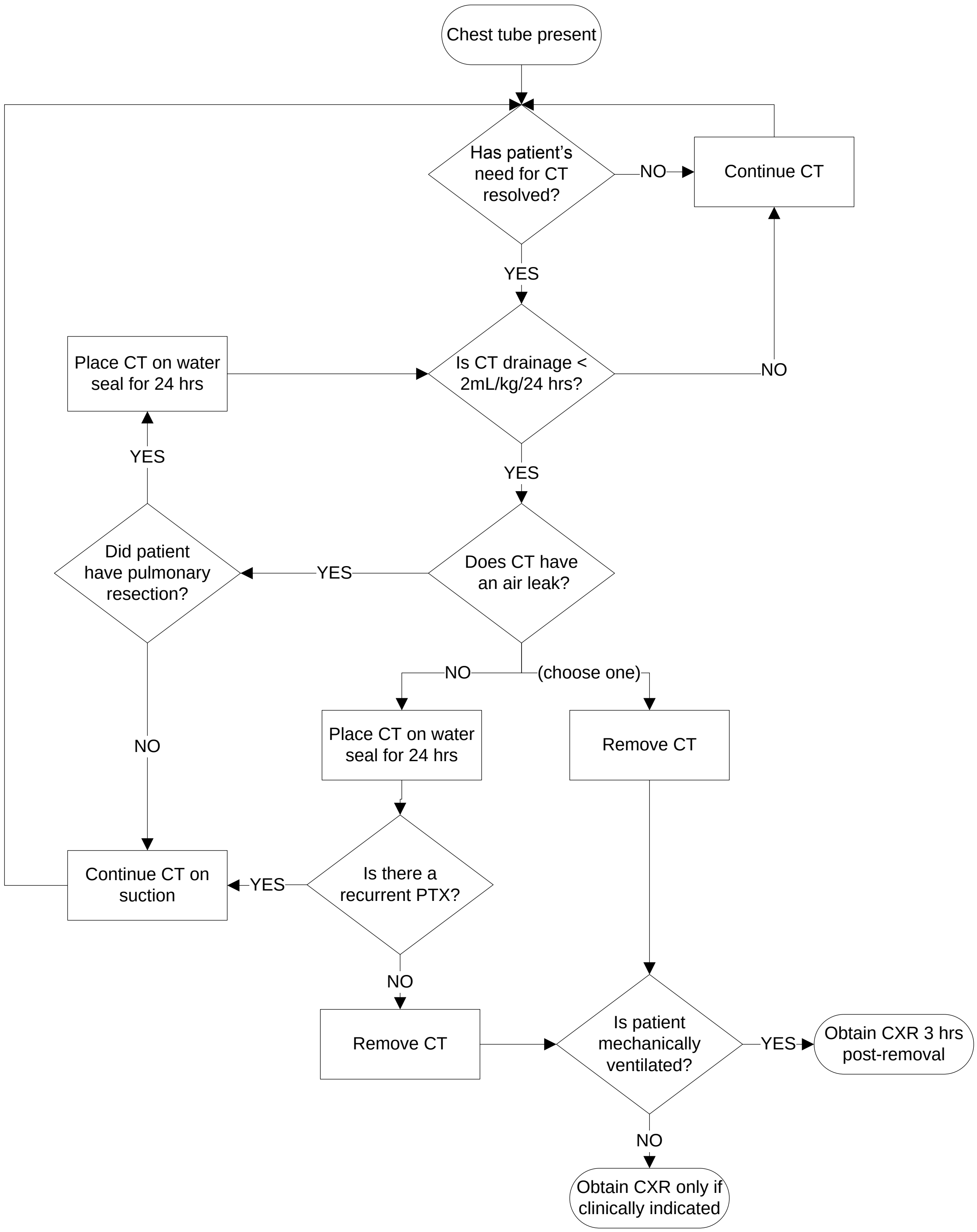
CHEST TUBE MANAGEMENT ALGORITHM



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