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# Accuracy of targeted wire guided tube thoracostomy in comparison to classical surgical chest tube placement – A clinical study

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ABSTRACT

*Background:* Chest tube malfunction, after the tube thoracostomy, is often the result of an inappropriate chest tube tip position. The aim of this study was to analyse the precision of chest tube placement using the targeted wire guide technique (TWG technique) with curve dilator and to compare it to the classical surgical technique (CS technique).
*Materials and methods:* In this clinical study 80 patients with an indication for thoracic drainage, due to pneumothorax or pleural effusion were included. Experimental group contained 39 patients whose chest tube was placed using the TWG technique. The control group contained 41 patients whose chest tube was placed using the CS technique.
*Results:* The comparison of the outcomes of the two techniques applied suggests that the TWG technique was significantly more successful in achieving adequate (precise) chest tube placement, irrespective of patient diagnosis (TWG vs. CS in all patients, 78.4% vs. 36.6%, $p < 0.001$). In the pleural effusion group, TWG and CS had success rates of 78.2% and 37.5% ($p = 0.005$), respectively, while in pneumothorax group, TWG and CS had success rates of 78.6% and 35.3% ($p = 0.029$), respectively.
*Conclusions:* Using a curved dilator and the TWG technique for the thoracic drainage procedure we found statistically significant advantage to the TWG technique in comparison to the CS technique (78% vs. 37%) regarding precise chest tube placement within the pleural cavity.

Introducing the materials and technique used in this clinical trial into clinical practice may improve the quality of thoracic drainage, including residual volume of air and/or fluid, poor functioning of the chest tube, and, as a consequence of both, prolonged hospitalisation.



## Introduction

Tube thoracostomy is a procedure required for free pleural air and pleural fluid drainage. Although thoracic drainage is considered to be simple and is a frequently used procedure, numerous complications have been recorded, including some life-threatening conditions [1–4]. Thoracic drainage complications can be divided in two groups: (a) intrathoracic and intraabdominal injury or injury of the thoracic wall and (b) malfunctioning of the chest tube. Chest tube malfunction in clinical practice is the result of an inadequate insertion site, inappropriate chest tube tip position or the incorrect choice of the type and thickness of the chest tube [5,6]. Chen et al. showed that precise chest tube placement at the end of thoracoscopy results in better recovery and a shorter length of stay in the hospital [7]. In our previous pilot cadaver study we have proved that the success of the chest tube placement in accurate position was significantly higher by the targeted wire guide technique using a curved dilator (originally from a percutaneous tracheostomy set) in comparison with classical surgical technique [8].

The aim of this study was to analyse the precision of chest tube placement in clinical settings using the same targeted wire guide

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technique (TWG technique) as in the cadaver study and to compare it to the classical surgical technique (CS technique). This clinical trial was approved by the Ethical Committee of the University Hospital in Rijeka (Class: 003-06/11-01/13, Reg. no 2170-29-02/1-11-2).

## Materials and methods

Study was performed in the pulmonary ICU and 80 following patients with an indication for thoracic drainage were included. It is prospective observational clinical trial on patients with pneumothorax or pleural effusions who were randomly selected by the software program DatInf Ranolist (DatInf GmbH, Tubingen, Germany) and divided into two groups. Diagnostic of the above mentioned pathology was performed by chest X-ray and chest ultrasound with additional ultrasound examination of the chest wall at the chest tube insertion site. Predominantly our ultrasound examination was based on B-line (“Comet tail”) and pleural sliding in accordance with the recent recommendation [9]. The experimental group contained 39 patients whose chest tube was placed using the TWG technique. The control group contained 41 patients whose chest tube was placed using the CS technique. The exclusion criteria for this study were as follows: calcified pachypleuritis, adherent lung to the chest wall at the chest tube insertion site, coagulopathy/increased risk of bleeding, infection (cellulitis) overlying the puncture site and previous thoracotomy. Further exclusion criteria were haemodynamically unstable patients and/or patients with acute respiratory failure requiring mechanical ventilation. Dividing pleural space in four quadrants (back-up, back-down, front-up and front-down), mid axillary line was considered the border between front and back part and 5th rib in the mid axillary line was considered the border between up and down position in the thoracic cavity. Outcome of the two procedures was considered successful if tip of the chest tube was located in a previously targeted position: back-down for liquidothorax and front-up for pneumothorax. The success rate was calculated as number of precise chest tube placements relative to the total number of tube thoracostomy performed. Informed consents were obtained on all patients prior they enter the study.

### *Materials*

In the test group, a curved dilator was applied, which is a novel application for targeted thoracic drainage. We modified the instrument (curved dilator) so that is can be tailored to the needs of targeted guide wire assisted thoracic drainage. The curved dilator for targeted thoracic drainage consists of a straight and partially curved region. The diameter of the body progressively decreases after the straight portion of the dilator so that the tip of the dilator, which first enters the chest, is slightly larger than the diameter of the canal for wire guidance (Fig. 1). Because of the fast retraction of human tissue after dilatation, we designed an introducer with a centrally positioned canal for the guide wire that was fit to the chest tube Ch 28. The curved dilator and introducer are made according to ISO standards required for the development of this type of the medical devices (polycarbonate-ISO, thermal plastic filament for Stratasys® FDM™ modeler, Stratasys Inc., 14950 Martin Drive, Minneapolis, MN 55344-2020 USA). The other medical devices required for the TWG technique are routinely used in clinical practice; Tuchy needle18 G (10 cm) with 10 ml syringe from epidural catheter set (B. Braun Medical Inc., 824 Twelfth Avenue, Bethlehem, PA 18018), guide wire (70 cm) and scalpel. In both group, regardless which technique we had performed (TWG or CS technique) we always used the same 28 French (F) chest tube size.

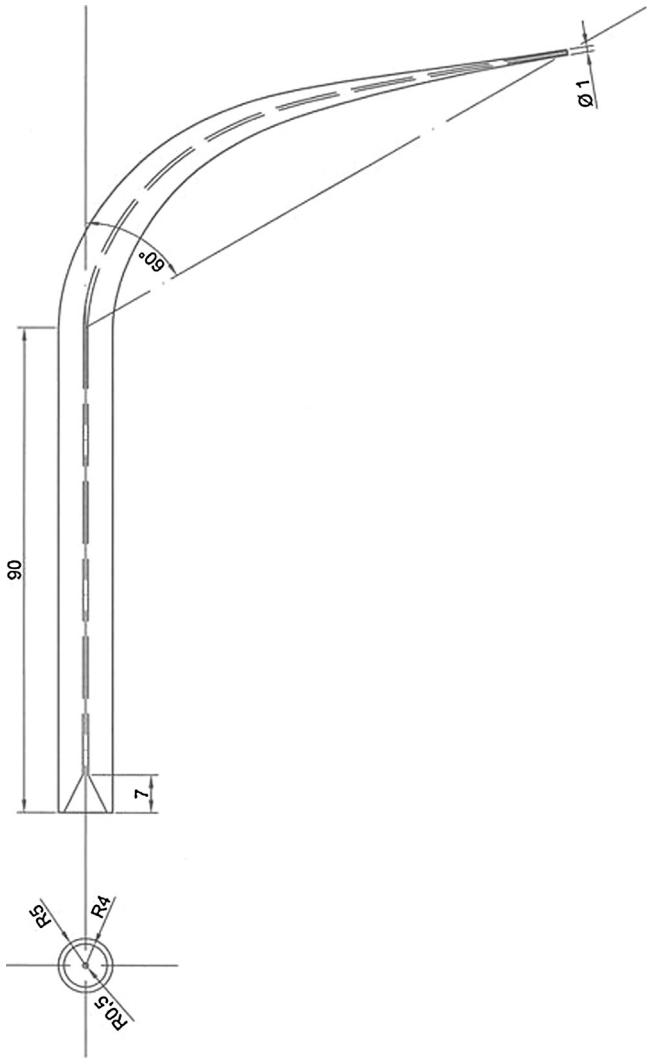


**Fig. 1.** Curved dilator for targeted thoracic drainage (all measures are in metric system – mm). (R – Radius).

### *Methods*

#### *Targeted wire guide technique*

All TWG procedures were performed by two investigators with the same experience (AP and IB). At the level of the fifth intercostal space in the mid-axillary line, 10 ml of lidocaine 2% was applied to each patient. In the locally anesthetised area, a 1 cm skin cut was performed. We entered through the cutting wound and proceeded with a Tuchy needle 18 G (needle with a blunt tip) using the technique “loss of resistance”. By the end of expiration, while the tip of the needle was entering the pleural cavity, we introduced a wire guide (marked every 5 cm) into the pleural cavity. After guide wire insertion into the pleural cavity using the Tuchy needle, the dilatation of a hole was performed using the curved dilator. The dilator was introduced into the thoracic cavity up to the beginning of its curved part portion, and then the guide wire was pulled out up to the marking of 20 cm. Thus, the tip of the guide wire just entered into the body of the curved dilator. Rotation around the long axis of the dilator handle enables the tip of the dilator to be directed towards the intended chest quadrant. To insert the chest tube for pleural air drainage (pneumothorax), the tip of the dilator was directed up-front. To insert the chest tube for pleural fluid drainage, the tip of the dilator was directed down-back. In both situations, after we assured that the tip of the curved dilator