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# Pericardium matrix buttressing hinders the stapled bronchial stump healing

*Jacopo Vannucci, MD,*[a,*] *Gian Luca Gervasi, MSc,*[b] *Marco Freddolini, PhD,*[b] *Alessandra Pistilli, PhD,*[c] *Valentina De Monte, DVM, PhD,*[d] *Antonello Bufalari, DVM, PhD,*[d] *Mario Rende, MD,*[c] *and Francesco Puma, MD*[a]

[a] *Department of Thoracic Surgery, University of Perugia Medical School, Perugia, Italy*
[b] *Istituto di Ricerca Traslazionale per l'Apparato Locomotore Nicola Cerulli—LPMRI, Arezzo, Italy*
[c] *Anatomy Section, Department of Surgery and Biomedical Sciences, University of Perugia Medical School, Perugia, Italy*
[d] *Department of Veterinary Sciences, University of Perugia, Perugia, Italy*

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ABSTRACT

*Background:* Biomechanical and histological properties of stapled bronchi with and without bovine pericardial matrix plus collagen reinforcement are analyzed.
*Materials and methods:* Pneumonectomy with mechanical bronchial suture was performed in the swine model. Pigs were randomly assigned to three groups: three-row staplers without reinforcement (*Traditional*), with reinforcement (*Buttressed*) and control "wild type", non-resected normal bronchus (*Normal*). Intraoperative test was carried for air leaks at 20/30/40 mm Hg endobronchial pressure. After 60 d, tracheobronchial specimen was harvested, stocked, and analyzed. Tensile test was performed using INSTRON 5965 loading frame machine. Maximal strain resistance value, length of elongation at rupture parameter, and stiffness coefficient (K) were evaluated. Histological analysis was performed. Sample size calculation was assessed (four per group), and the Student *t*-test was used to statistically evaluate differences in biomechanical variables.
*Results:* No fistula occurred. Biomechanical analysis showed that maximal strain resistance is 41.22 ± 2.11 N (*Traditional*), 24.53 ± 3.47 N (*Buttressed*), and 30.91 ± 0.29 N (*Normal*); elongation at rupture is 16.01 ± 1.82 mm (*Traditional*), 12.89 ± 0.48 mm (*Buttressed*), and 9.32 ± 0.11 mm (*Normal*). Finally, K is 2.59 ± 0.16 N/mm (*Traditional*), 1.91 ± 0.33 N/mm (*Buttressed*), and 3.32 ± 0.01 N/mm (*Normal*). Stumps without reinforcement proved higher resistance and length of elongation than reinforced ones. Normal bronchial tissue shows the highest stiffness coefficient. Statistical analysis produced significant values for each biomechanical feature. Group *Buttressed* stumps show greater thickness and a substantial inflammatory reaction with granulation tissue along the whole scar and around areas of discontinuity within the scar, not yet healed.

* *Corresponding author*. Department of Thoracic Surgery, University of Perugia Medical School, Loc. Sant'Andrea delle Fratte, 06134 Perugia, Italy. Tel.: +39 075 5782267; fax: +39 075 5782600.
E-mail address: jacopovannucci@tiscali.it (J. Vannucci).
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*Conclusions:* Reinforcing the mechanical suture line of bronchial stump with bovine pericardial matrix plus collagen shows suboptimal biomechanical and histological characteristics compared to using the stapler alone.



## 1. Introduction

Bronchial stapling is currently the preferred technique when performing anatomic pulmonary resections [1]. Despite the great evolution of staplers and medical equipment, there is some debate regarding the absolute reliability of such devices that are still perfectible [2]. Although traditional suturing can be advocated for several reasons, the development of minimally invasive surgery for major lung resection gives staplers a crucial role. In the past, the hypothesis of stapler reinforcement with biotech products was formulated for peripheral lung resections to help reduce air leaks [3]. Thoracic surgery is not the only field in which the potential benefit of suture line protection has been examined. Several authors have actually investigated various methods and techniques for mechanical suture reinforcement or protection. Particular interest has been focused on pericardium properties, which were used in clinical and experimental settings, and different technical objectives have been explored [4–7].

In this study, stapler's prongs coverage with bovine pericardium matrix plus collagen has been evaluated in the large animal model and compared to bare stapler's outcome. The aim of the investigation was to basically analyze and compare the biomechanical and histological properties of the bronchial stumps undergoing the aforementioned suture techniques along with possible differences in the clinical results offered. The assessment of differences is carried out with the additional analysis of normal bronchial tissue properties, belonging to pigs that had not undergone surgical manipulation, to better contextualize the study findings. The research seeks to generate hypothesis for future improvement of applied surgical technology.

## 2. Material and methods

The experimental protocol was evaluated and approved by Local and Central Authorities for Animal Care. The study was performed on Landrace × Large White pigs (40 ± 5 kg) to fully simulate the technical procedures currently used in surgery for humans. Methodology, instruments, and perioperative arrangements strictly followed medical principles and performances of our Hospital Standard of Behaviour.

After adaptation and clinical observation for 1 wk at the experimental center, calculated numbers of necessary 12 pigs (see Section 2.3) were randomized into three groups and submitted to left pneumonectomy through thoracotomy [8]. The pneumonectomy was carried out by traditional dissection of hilar components; pulmonary veins were tied, pulmonary artery division was achieved mechanically (Endo GIA stapler, 30 vascular load; Covidien, Minneapolis, MN), and finally, bronchial closure was performed with the same stapler, according to the following scheme:

1. Traditional stapling (*Traditional* ): Covidien Endo GIA purple load (n = 4)
2. Buttressed stapling (*Buttressed* ): Covidien Endo GIA purple load + bovine pericardium matrix plus collagen reinforcement (Veritas; Synovis, St Paul, MN; n = 4)
3. Normal tissue (*Normal* ): control—"wild type," non-resected normal bronchus strip (n = 4)

The comparison is carried out between the traditional suture methodology and with buttressing device. The normal tissue's biomechanical analysis is performed to have a baseline context for the analysis of experimental findings and the value of variations.

Pigs were submitted to surgery once caregivers were convinced of their overall healthy condition. After pneumonectomy, animals of Group *Traditional* and Group *Buttressed* were intensively followed up for 3 d, then stalled in single boxes at 18°C (air temperature), with drinking water *ad libitum* and food twice a day. Boxes were sanitized daily. The postoperative course was strictly monitored. Vital parameters, fever, feeding, behavior, growth, and clinical issues were recorded every 12 h. Group *Normal* animals were not submitted to pulmonary resection but were followed up exactly like Groups *Traditional* and *Buttressed*.

Part of the analysis was intraoperatively performed with tests for air leaks and stump reliability at 20, 30, and 40 mm Hg positive endobronchial pressure (steady pressure each level for 5 s). All animals were painlessly euthanized on the 60th postoperative day. During the autopsy, signs of pleural disease, past infections, and left peribronchial impairments were investigated. Tracheobronchial specimens were harvested, stocked in phosphates-buffered saline, and immediately transferred to the biomechanical laboratory.

### 2.1. *Biomechanical testing*

Biomechanical tests were performed as previously described [9]. At the bench, bronchial stumps were fashioned to test their biomechanical properties. More specifically, the maximal strain resistance value (MSR), the length of elongation at rupture (ER) parameter, and stiffness coefficient (K) were measured. MSR represents the maximum force that can be applied to the sutured bronchus before failure, and it indicates the maximal resistance to an axial load. ER represents in millimeters how much the sutured bronchus was stretched when the maximum force was applied. Stiffness coefficient indicates the rigidity of the sutured bronchus, in particular, a higher value of stiffness indicates a little deformation of the