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Experimental left pneumonectomy in pigs: procedure and management

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ABSTRACT

Background: Because there is no detailed description of procedures and perioperative management of major pulmonary resections in swine, we reviewed our experience to delineate the most effective practice in performing left pneumonectomy.

Materials and methods: Analysis of 11 consecutive left pneumonectomies. Animal data, operative reports, anesthesia records, and perioperative facts were evaluated. Follow-up information until postoperative day 60, methods of care-taking, therapy administration, and all the stabling aspects were systematically assessed. The investigation was aimed at highlighting those procedural steps or details which make the difference in optimizing the available resources (animals, instruments, and personnel). No statistical analysis was performed considering data characteristics and the descriptive nature of information.

Results: Surgery requires a median time of 2 h and 16 min; two operators and one anesthesiologist represent the basic team. Circulators' number depends on goals to accomplish. The most straightforward procedure requires careful dissection of the pulmonary ligament (limited view), pulmonary veins (low variability), pulmonary artery (delicate), and finally bronchus (no variability observed). The key factors for good anesthesia management have been identified: sedation by caregivers, preoxygenation before induction of general anesthesia, high respiratory rates with low tidal volume after pneumonectomy, and noninvasive ventilation after extubation. Antibiotic prophylaxis has been performed. Postoperative care must be continuous until animals are able to stand up, afterward "preventive noncurative," and always animal friendly. Ideas for minimally stressful therapy administration are helpful.

Conclusions: After the delineation of this methodology, the compliance to a routine practice allowed us to reduce time, stress, and cost; quality and quantity of possible research increased.

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1. Introduction

Recent advances in animal laboratory have led to consistent evolution of experimental surgery research. Stricter regulations and attention to a model's reliability have assisted the improvement of research quality. Alongside this, there have been several developments in surgical models, whether for technical evolution in surgical procedures [1] or for functional research requiring a surgical operation [2]. Despite the progress of large animal models, some aspects still need to be clarified, especially concerning those models that are most commonly used, to give more space for comparison between different studies and a more straightforward execution of procedures. Among large models, pig, dog, and sheep are the preferred choices for surgical research but pig is becoming more and more attractive because of different characteristics (anatomy, previous knowledge, costs, necessary space, aggressiveness, sociality, and so forth). A very important additional factor to focus on the swine model is that the canine is no longer available in most European countries for regulatory changes.

A large number of investigations requiring pneumonectomy (PNCT) on animal model have been published but most of these articles just report that PNCT is performed, no details are often reported regarding pre-operative, intra-operative, and post-operative periods; thus, the operative phase of each research is carried out differently. This substantial lack was already denoted by Swindle [3] in his exceptional contribution regarding techniques and management of the swine model in which some information on how-to-do-it is given but it is still not sufficient to standardize the technique.

The aim of this study was, therefore, to outline the best routine to prepare, perform, and follow up a left PNCT in swine to give specific information so as to reduce operators' learning curve, surgical morbidity, animal stress, and investigator hesitation, as well as to extent comparability, to increase efficiency enhancing the focus on the main research and to assist the immediate procedure reproducibility for beginners.

2. Materials and methods

Left PNCT in female 35.81 ± 6.44 kg swine is used in our Experimental Surgery Laboratory for different investigational purposes, and it is preferred over the contralateral because of the right tracheal bronchus, normally found in swine, and due to its inferior volume (right/left: 4/3) [4]. All the procedures were carried out in accordance with Local and Central Authorities for Animal Care and following the "Guide for the Care and Use of Laboratory Animals" (NIH publication, eight edition 1996).

Regardless of what the research objective was, we reviewed our preliminary experience on 11 models. Surgery reports and anesthesia records have been evaluated in each procedural category (techniques, instruments, timing, troubles, concerns, unexpected events, and variability). Animal behavior and reaction to manipulation were registered by caregivers and subsequently analyzed to assess the animal response to stabling, adaptation to environmental changes, feeding strategy, compliance to therapy administration, and follow-up observation during the standard period from preoperative day 7 to postoperative day 60. The operating room layout, team members, and ordinary schedule (collegial meeting, routine organization, and operating room pacing) have been evaluated to assess the major issues, necessity of human and material resources, time managing, and preparation of second phase (research protocols).

Considering the descriptive variables, the data collection methodology, and the sample size, no statistical analysis was performed. The numeric records were analyzed by the properties of Microsoft Excel (Microsoft Corp, Redmond, WA).

3. Results

3.1. *Documental records*

Animals can be restless, potentially, for a period of a week after arrival; manipulation (physical examination and contact) could be a trigger for an aggressive reaction. Caregivers might report different findings if they are several and if collegiality is limited with daily staff turnover. More than three feeding rounds can cause the animal's attitude to fluctuate, which can lead to increasing difficulty for medical screening. Pigs look for water if it is not constantly available. Animals show friendly behavior to two constant caregivers (active approach instead of defense position).

Premedication effects before surgery are predictable if carried out by constant caregivers while it is less straightforward with possible stress if unknown researchers perform it. Stressful premedication led to troublesome induction of general anesthesia in three cases. Given that the intubation of swine is rather laborious and sometimes requires more time compared with other species, preoxygenation before the induction of general anesthesia has proved to play an important role in balancing the oxygenation safety margin in the case of prolonged apnea at the moment of induction of anesthesia.

Before PNCT, a moment of hypotension (mean arterial pressure <60 mm Hg) in a pig was treated and solved by lowering the sevoflurane inhalation (2%) and administering 10 μg/kg/min of dobutamine for 20 min. A pig with an otherwise straightforward anesthetic procedure was reintubated soon after the extubation because apnea and mild cyanosis were noted. After 10 min of spontaneous respiration with pure oxygen, the pig was extubated and noninvasive ventilation (NIV) was introduced. High respiratory rates (up to 50 breaths/min) and a low tidal volume (TV; 8 mL/kg) are required after the PNCT. NIV has been reported to be a valuable option to assist respiration soon after extubation. Despite myoresolution being continually achieved, we encountered muscle contraction at parietal level during electrocautery use.

Surgery was approached as it is for humans. Anatomic variability was minimal. We reported the absence of azygos (1) and right posterior pulmonary vein (PV) flowing into the left posterior PV (1). Mortality (1) and morbidity (3) were detailed. Morbidity was characterized by mild transient hemoptysis (36 h, bronchial stump bleeding), third week constant fever