



(RESEARCH ARTICLE)



Assessing the respiratory impact caused when giant hernias are reinserted into the abdominal cavity, in order to determine the optimal surgical approach

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Abstract

The reinsertion of a large hernia into the abdominal cavity provokes an increase in abdominal volume and pressure that can result in intra-abdominal hypertension. This, in turn, may generate a series of complex changes in cardiopulmonary physiology and induce severe respiratory insufficiency.

At present, no objective method exists to evaluate the possibility of this respiratory complication occurring. Accordingly, the present study was undertaken to measure the respiratory consequences of abdominal volume restriction. The data obtained were used to construct a reference table, from which the reduction in FEV1 can be predicted according to the hernia volume reinserted. Thus, the surgeon has access to more accurate information, which greatly facilitates the treatment of large abdominal hernias.

Key words: Giant hernia; Volume; Repair; Respiratory; Abdominal cavity

1. Introduction

In all laparotomies, the incidence of incisional hernias is 20%, with a known risk ranging from 14% to 20% [1,2].

Surgical procedures requiring an extensive approach, as is the case of hepatic or pancreatic incisional interventions such as Ross's bilateral subcostal incision, West's extended transverse incision [3] or large midline laparotomies, increase the probability of large defects appearing in the anterior abdominal wall.

For these patients, surgery is dangerous due to the risk of acute postoperative respiratory failure following the displacement of the large hernial content from the abdominal cavity. Its reinsertion increases abdominal volume and pressure, which may provoke intra-abdominal hypertension and abdominal compartment syndrome [4].

The abdominal cavity is anatomically related to the rib cage through the diaphragm muscle. Using animal and human models, studies have shown that, an average of 50% (range 25-80%) of intra-abdominal pressure is transmitted to intrathoracic pressure [5]. Intra-abdominal hypertension generates a series of complex changes in cardiopulmonary physiology that can lead to postoperative complications such as acute respiratory failure and, in the worst case, the appearance of a secondary respiratory distress syndrome [6].

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The fundamental problem that arises when intra-abdominal hypertension exerts pressure on the thorax is a change in ventilatory mechanics that induces pulmonary restriction. This loss of lung capacity in the form of restrictive ventilatory failure increases the risk of postoperative cardiorespiratory complications.

Furthermore, this risk is not limited to the first 24 hours postsurgery, but can also manifest in the medium and long term. For this reason, patients should be closely monitored during the postoperative period to detect early symptoms of acute, life-threatening respiratory failure. The management of this type of patient remains an ongoing challenge for abdominal wall surgeons.

Accordingly, there exists a particular group of patients with very large hernias for whom surgery is contraindicated due to the possibility of severe cardio-respiratory problems. In such cases, the volume transposition technique is recommended, to ensure there is absolutely no loss of lung volume [7].

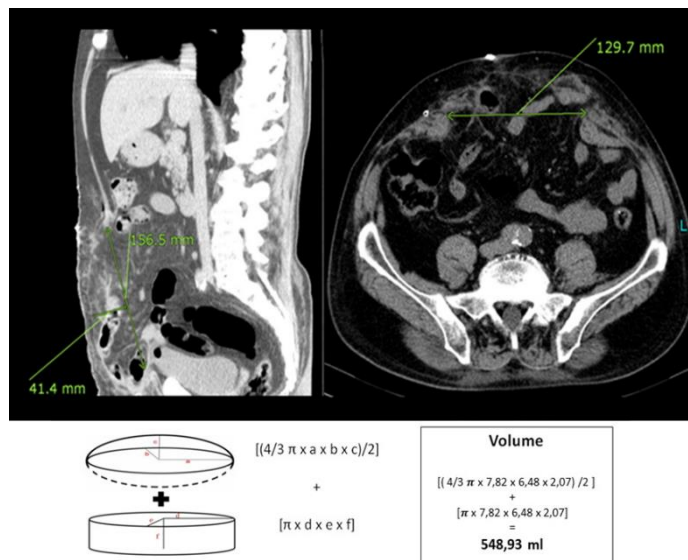


Figure 1 Preoperative CT to calculate the volume of the hernia.

This intervention is based on the transposition of volumes, given the extremely high risk involved if intraperitoneal volume is even minimally increased. A preoperative CT is requested in order to calculate the volume of the hernia (Fig. 1). The hernia sac is assumed to be cylindrical, terminating in a semi-ellipse, and so the following formula is used: volume = $\pi \times d \times e \times f$ (the volume of a cylinder, where d and e are the radii of the base and f is the height) + $(4/3 \pi \times a \times b \times c)/2$ (volume of a semi-ellipse, where a is the longer radius, b is the shorter radius and c is half of the height). The surgical technique used is to repair the hernia without increasing the intraperitoneal volume, so that the hernia volume is contained within a Proceed® mesh. To achieve this outcome, the mesh is inserted in such a way that no tension is exerted on the abdominal walls, as if it were the sail on a dinghy (Fig. 2). By this means, we are able to increase the capacity of the intraperitoneal compartment by the same volume as had previously been contained in the hernia.

In recent years, the above technique has been applied at our hospital to patients presenting a large hernia and experiencing severe respiratory failure, with good results.

However, similar problems may arise for other patients. Even when a giant hernia causes little or no respiratory difficulty, the reinsertion of the hernial content may result in severe postoperative respiratory distress. To our knowledge, no parameters exist, according to the patient's baseline respiratory status, as an objective guide to the hernial volume that may safely be reintroduced into the cavity.

Accordingly, and following a prior study by Angelici et al. [8], we have devised a formula (see Fig. 3) to estimate the increase in intra-abdominal pressure that would be produced when a given volume of hernial content is reintroduced into the cavity. This approach, taken in conjunction with the findings of Ruiz Ferron et al. [9] regarding the severity of pulmonary complications according to the degree of intra-abdominal pressure observed, enables us to obtain an objective parameter. This method has now been used for several years to calculate the approximate hernial volume that can be reintroduced with minimal risk of postoperative complications.

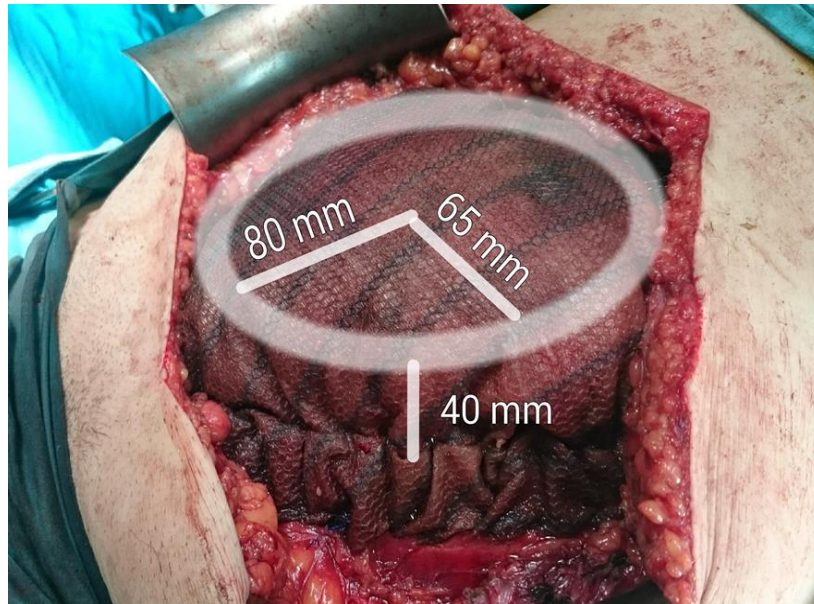


Figure 2 Mesh attached with a double crown of continuous nonabsorbable sutures.

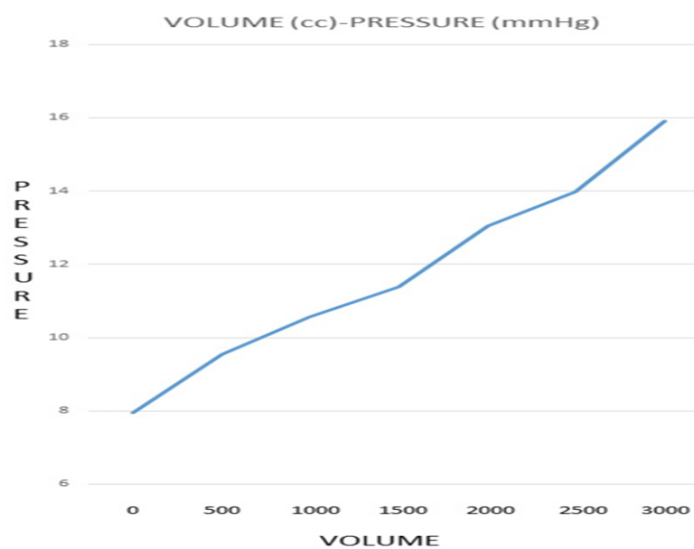


Figure 3 Estimate increase in intra-abdominal pressure that would be produced when a given volume of hernial content is reintroduced into the cavity.

We now seek to advance this process, to calculate the exact volume that can be reintroduced into the abdominal cavity without the risk of postoperative respiratory complications, for each patient individually. As commented above, changes in abdominal pressure and volume are transmitted to the thorax, which in turn induces changes in ventilatory mechanics, in the form of pulmonary restriction. The spirometric parameter commonly used to measure lung restriction is that of forced vital capacity (FVC). However, any lung disease that causes restrictive ventilatory failure affects all lung volumes proportionally, including that of forced expiratory volume in 1 second (FEV1). Many attempts have been made to use the patient's baseline FEV1 before surgery to predict postsurgical respiratory complications, but to date results have been inconclusive [10]. In lung resection surgery for patients with bronchogenic cancer, the post-operative predicted FEV1 (FEV1-ppo) is calculated to estimate the surgical risk presented. For this type of thoracic surgery, in which a lobectomy or pneumonectomy by definition entails pulmonary restriction, there is solid evidence that surgical risk is related to FEV1-ppo [11], and it is well established that this parameter is the most reliable means of identifying patients at high surgical risk in lung tumour interventions. In the preoperative assessment of a patient scheduled for lung resection, it is common practice to estimate postoperative lung function via FEV1-ppo. Patients are considered operable if FEV1-ppo >40% [12]. The value of this parameter as a predictor of postsurgical respiratory complications

in abdominal surgery has not yet been validated [13], but until it is, we believe it reasonable to use it as a cut-off point, considering the anatomical and functional relationships between the abdominal and thoracic cavities and the mounting evidence that changes in abdominal pressure are transmitted to the thorax.

For all these reasons, at our hospital, patients with abdominal hernias are given a preoperative respiratory functional study. In this process (Fig. 4), an abdominal girdle is applied, covering the upper and lower abdomen, into which bags of physiological saline are inserted, to gradually increase the abdominal volume (in steps of 500 cc), thus inducing a progressive pulmonary restriction. After each such increase in volume, a spirometry test is performed. For each patient we thus obtain a FEV1-ppo curve for the volume of hernial content reinserted. This parameter allows us to calculate the increase in intra-abdominal volume the patient could withstand, at minimal postoperative risk. This knowledge, during the intervention, reveals the extent to which the hernial volume can be reduced, and which of the following options should be adopted

- If the patient's respiratory status does not allow any volume to be reduced, the volume transposition technique is indicated, with which the entire hernial content is retained beneath the mesh, and there is no increase in abdominal volume.
- A partial reduction of the hernia can be performed. The amount can be calculated exactly, thus facilitating a partial transposition of volumes, in which the hernial content is reduced to the maximum amount possible for the case in question, while the balance remains beneath the mesh.
- The entire hernial content can be reduced, after which the abdominal wall can be closed, and an appropriate repair technique can be performed.

Using the data recorded to date for our patients, we are currently preparing an indicative table of the impact on the FEV1-ppo of the hernial volume inserted (see Preliminary results, Fig. 5). Thus, given the total volume of the hernia and the patient's FEV1-ppo, the surgeon can use the table to determine the exact quantity of hernial content that can safely be reintroduced into the cavity, with minimal risk of respiratory complications.

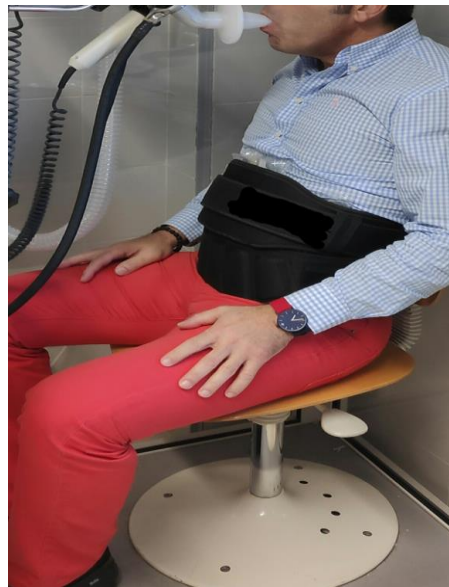


Figure 4 Spirometry with progressive abdominal volume restriction.

In summary, the proposed table predicts the decrease in FEV1-ppo presented by the patient according to the hernial volume reinserted. This information enables us to make a preoperative assessment of surgical risk, based on the volume of the hernia, similar to that made by thoracic surgeons based on the amount of lung to be resected in patients with bronchogenic cancer. In the knowledge that when FEV1-ppo <40% the patient must be considered inoperable, the individual FEV1-ppo curve can be used to extrapolate the maximum hernial volume that can be reinserted during the intervention, thus ensuring that the final expected FEV1-ppo remains above the threshold and reducing the likelihood of post-surgical respiratory complications.

Very soon, we hope to publish the results obtained for the FEV1-ppo curve for a significant sample of patients. We believe this parameter will be greatly helpful to abdominal wall surgeons, enabling them to decide the optimal type of treatment for these complex hernias.

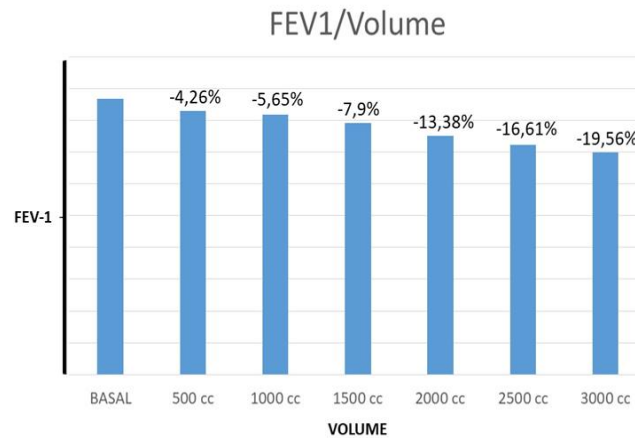


Figure 5 Orientative table of the impact produced on FEV1-ppo by the hernial volume reinserted into the abdominal cavity.

Compliance with ethical standards

Disclosure of conflict of interest

The corresponding authors have no conflicts of interest.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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