

## Original Article

# Subxiphoid Incisional Hernia Treatment: a Technique Using a Double Mesh Adjusted to the Defect

Fernando Carbonell Tatay,\* Providencia García Pastor, José Bueno Lledó, María Saurí Ortiz, Santiago Bonafé Diana, José Iserte Hernández, Fernando Sastre Olamendi

Unidad de Cirugía de Pared Abdominal, Servicio de Cirugía General y del Aparato Digestivo, Hospital Universitario La Fe, Valencia, Spain

## ARTICLE INFORMATION

## Article history:

Received February 11, 2011

Accepted March 5, 2011

## Keywords:

Subxiphoid incisional hernia

Double mesh

Preperitoneal repair

Incisional hernia

## A B S T R A C T

**Introduction:** Subxiphoid incisional hernia has characteristics that differentiate it from the rest and make it a distinctive entity. The fact that it has its sac very near the rib cage and sternum determines the pressure in the margins. The repair, by open or by laparoscopic approach, has not demonstrated good results despite the generalised use of a prosthesis. They are uncommon, and have a significant comorbidity in patients (severe heart diseases, transplants, immunosuppressed), after surgery of the hepato-bilio-pancreatic area with transverse incisions, or very high mid-laparotomies for gastro-oesophageal surgery.

**Material and methods:** A new technique has been developed in our Unit, based on a double mesh and adapted to the anatomical and physiological characteristics of the region. The series consisted of 35 consecutive patients operated on between 2004 and 2010, following an agreed surgical and management protocol.

**Results:** There were no significant complications—the most frequent (17.4%) was a seroma—except one case of a wound infection due to skin ischaemia in one patient who had had multiple operations and a transplant. During the post-surgical follow up to the present (between 4 and 80 months), there has been no recurrence of the incisional hernia and no significant local discomfort has been reported.

**Conclusions:** The “adjusted double mesh” technique achieved good results in our hands, from the surgical point of view (reproducibility, recurrence), and for the patient, with minimal discomfort and recovery of quality of life..

© 2011 AEC. Published by Elsevier España, S.L. All rights reserved.

## Tratamiento de la eventración subxifoidea: técnica de doble malla ajustada al defecto

## R E S U M E N

**Introducción:** La eventración subxifoidea tiene características que la diferencian del resto y le dan entidad propia. El hecho de tener su saco muy próximo a los relieves costales óseos y esternón condiciona mucha tensión en los márgenes; la reparación, tanto por vía abierta

## Palabras clave:

Eventración subxifoidea

Doble prótesis

\*Corresponding author.

E-mail address: fernandocarbonelltatay@gmail.com (F. Carbonell Tatay).

## Reparación preperitoneal Hernia incisional

como laparoscópica, no ha demostrado buenos resultados a pesar del uso generalizado de prótesis. Son poco frecuentes y se presentan en pacientes con comorbilidad importante (cardiopatías severas, trasplantados, inmunodeprimidos), tras intervenciones del área hepato-bilio-pancreática con incisiones transversales, esternotomías ampliadas por debajo del xifoides o laparotomías medias muy altas para cirugía gastro-esofágica.

**Material y método:** En nuestra Unidad hemos desarrollado una nueva técnica, basada en el uso de doble prótesis y adaptada a las características anatómo-fisiológicas de la región, para la reparación de estas eventraciones. La serie consta de 35 pacientes intervenidos de forma consecutiva entre 2004 y 2010, siguiendo protocolo quirúrgico y de manejo consensuado.

**Resultados:** No hubo complicaciones importantes –la más frecuente es el seroma, 17,4%–, excepto un caso de infección de la herida por isquemia de piel en un paciente multioperado y trasplantado. El seguimiento postoperatorio hasta el día de hoy (entre 4 y 80 meses) no ha demostrado recidivas de la eventración y no se refieren molestias locales importantes.

**Conclusiones:** La técnica «doble malla ajustada» consigue en nuestro medio unos buenos resultados, tanto desde el punto de vista del cirujano (reproducibilidad, recidiva) como del paciente, con mínimas molestias y recuperación de la calidad de vida.

© 2011 AEC. Publicado por Elsevier España, S.L. Todos los derechos reservados.

## Introduction

A hernia is a very common surgical complication,<sup>1</sup> with an incidence of up to 30%. A subxiphoid hernia has its own characteristics, according to the current EHS classification.<sup>2</sup> It appears as a proximal defect in very high mid-laparotomies—frequently associated with a xiphoid excision—after transverse incisions or extensive sternotomy for cardiac surgery in patients with high comorbidity (e.g., immunosuppression, anticoagulation, chemotherapy).

The xiphoid process<sup>3</sup> is a hyaline cartilage process which is almost completely ossified. The peri- or subxiphoid region, through which the incisional hernia sac protrudes, is the insertion point for several muscles: the anterior rectus abdominis, its sheath and linea alba are inserted in the anterior portion of the xiphoid process, which extends caudally into the posterior wall of the sheath. There are also 3 other linkage systems: the costal-xiphoid ligament, from the 7<sup>th</sup> costal cartilage to the sides of the xiphoid process, the transverse muscle of the thorax, from the 6<sup>th</sup> rib to the xiphoid process; and the sternal portion of the diaphragm, which is inserted into the xiphoid posterior surface. The area is fed by the xiphoid artery, a branch of the internal thoracic artery, or the upper branches of the epigastric artery. Destruction of this interconnected tissue, which normally supports thoraco-abdominal pressure, determines an incisional hernia.

The incidence of incisional hernia after median sternotomy in cardiac surgery is between 1% and 4.2%,<sup>4,5</sup> which is probably underestimated because they are usually small and asymptomatic, as the liver prevents intestinal incarceration. In most series, the repair was elective<sup>6</sup> and incarceration was the exception.

The risk factors identified with its appearance are obesity, the need for transfusion during cardiac surgery, a transplant or immunosuppression history, and primary surgical wound infection.<sup>6</sup>

We know that the hernias with a sac close to bony prominences are difficult to resolve. Because direct repair has given poor results, a prosthesis implantation has become the standard procedure,<sup>7</sup> although with a considerable recurrence rate.<sup>6</sup> The laparoscopic approach has failed to improve results because attaching the mesh, which should always be away from the defect, is complex due to the anatomy of the region with the pericardial membrane and diaphragm being so close.

The aim of this study was to analyse the 6 years of experience and a representative series in repairing subxiphoid incisional hernias using the “adjusted double mesh” technique in our hospital.

## Material and Method

A prospective longitudinal study, which included all patients who underwent this “adjusted double mesh” technique between January 2004 and October 2010 was performed.

### Patient Selection

Those with a pure subxiphoid hernia, i.e., with a sac just below the xiphoid process and the costal margin, were considered. Mid-high hernias and epigastric ones were given a different treatment and not included.

### Preoperative Preparation and Treatment Protocol

All patients were studied by dynamic CT of the region (Figure 1) using the Valsalva manoeuvre, to evaluate the defect size and volume, their relationships and sac content<sup>8</sup> as this data provides valuable information.

As well as the routine preoperative tests, respiratory tests were considered, with respiratory physiotherapy prescribed

**Figure 1 – Dynamic CT image for preoperative assessment: hernia size, boundaries and content.**

with the help of a specialist. Given that obesity is a risk factor<sup>6</sup> for the onset and recurrence of hernias, we requested overweight patients to lose weight. The underlying disease had to be controlled (we did not interrupt immunosuppressive therapy in transplant patients), and cancer patients disease-free.

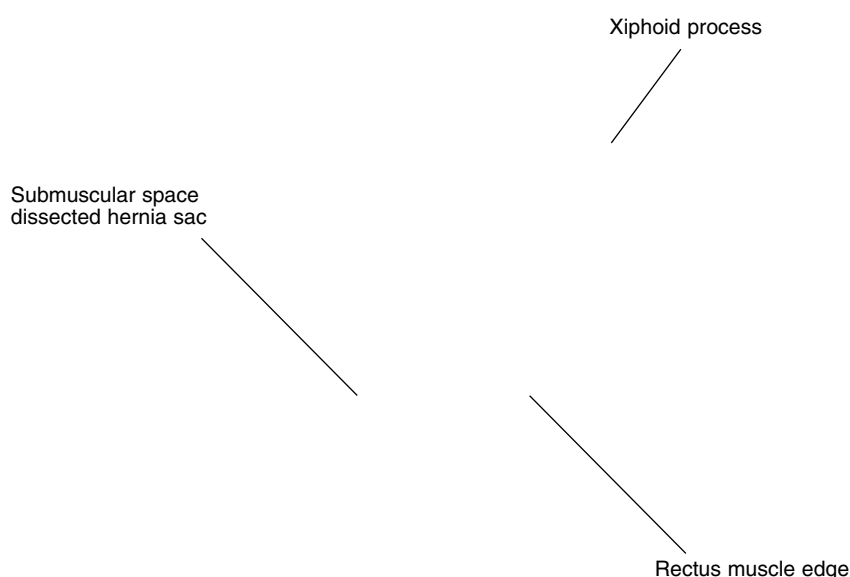
The operations were performed under general anaesthesia. We performed the antibiotic prophylaxis with amoxicillin-clavulanate (2 g, IV) before induction of anaesthesia (400 mg

IV ciprofloxacin in allergic patients) and antithrombotic prophylaxis with LMWH. Prior pneumoperitoneum was not needed in the series.

The postoperative period was in the hospital ward, with no cases in intensive monitoring. After discharge, there was monitoring at 1, 6, and 12 months, then annually.

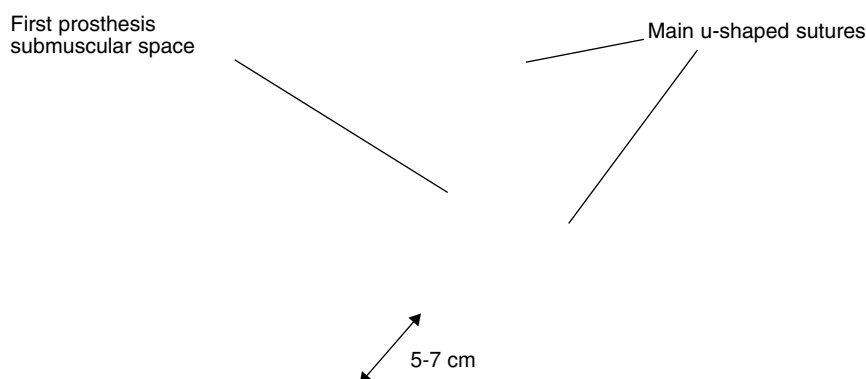
#### *Description of the Technique (Figures 2-5)*

- 1) Skin incision over the previous one, removing the scar.
- 2) Dissection of subcutaneous cell tissue to the aponeurosis, which is exposed about 10 cm around the hernia defect. Removal of the previous mesh if there was one.
- 3) Dissection of the sac to its neck and dissection of the preperitoneal layer. This gives a wide plane, isolating the peritoneum from its connections to the fascia with an alternating blunt dissection and an electric scalpel. In the proximal part: opening of the posterior sheath of the rectum muscles and cephalic dissection, obtaining enough space to insert the prosthesis. If any windows are seen in the peritoneum, they are closed with stitches or worked around if small, as the prosthesis to be placed here is suitable for contact with viscera.
- 4) The preperitoneal prosthesis is inserted. Measurement of the defect before cutting the prosthesis—either composite or polypropylene (PP) prosthesis—which had to be at least 5 cm bigger than the defect. Attachment via u-shaped transmuscular suture, including the prosthesis, which should not be knotted but used to position it well. Once in



The hernia sac is dissected and reinserted after obtaining a space below the muscle layer and above the peritoneum.

**Figure 2 – Dissection of the preperitoneal-retromuscular-retroxyphoid space.**



The first prosthesis is inserted, which is bilaminar, in the preperitoneal space, overlapping the defect by at least 5 cm. The pericardial membrane is controlled manually and sutured with u-shaped PP sutures, with the highest two behind the xiphoid process, and the following ones are equally spaced to cover the whole perimeter and keep the mesh taut.

**Figure 3 – First prosthesis (retromuscular) and attachment with individual transmural sutures.**

position, the sutures are gently pulled to fully extend the mesh in the submuscular space, and then progressively knotted. We used PP monofilament 2-0 sutures with a large atraumatic cylindrical needle, although Reverdin needles or suture pins like those used in laparoscopic surgery can be used too. However, we do not believe that this affects the final outcome.

- 5) Fibrin glue<sup>9</sup> (heterologous fibrin Tissucol® or autologous fibrin Vivostat® sealant) can be used to attach the prosthesis to the tissues and prevent dead space.
- 6) Adjustment of the second mesh to the defect. Because closing the gap can cause tension and wrinkle the prosthesis, we use a second flat PP mesh as replacement which is adjusted with continuous PP monofilament suture at the edges of the defect. A fibrin spray on the mesh can be applied, as it is fenestrated and has pores wide enough to let the product pass through.
- 7) Rigorous haemostasis of the subcutaneous space. Closure of the subcutaneous tissue and skin.

#### Data Analysis

A study database was designed for our series, and preoperative and intraoperative variables were determined: age, sex, comorbidity, presence of obesity (weight-height-BMI), smoking habit, previous surgery (cause, type of incision, related postoperative complications), associated medical treatment, ASA anaesthesia risk classification, hernia

(location, size, content), surgery (technical details, operation time, associated techniques), immediate and delayed postoperative complications, length of hospital stay and any recurrence. Also, a univariate analysis of risk factors involved in extending the hospital stay was done.

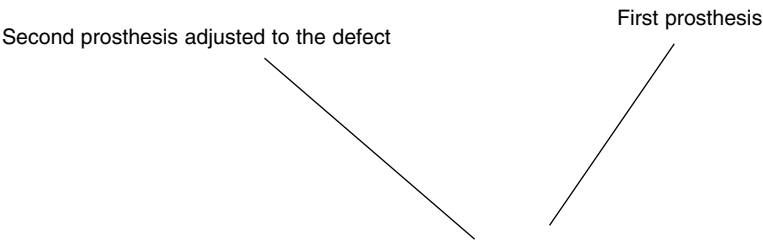
Statistical analysis was performed using the SPSS (version 15) commercial software program. Continuous variables were compared using the Student's t-test, with statistical significance set at  $P < .05$ . Dichotomous variables were analysed using the chi-square test and Fisher's exact test when necessary.

#### Results

Between January 2004 and October 2010, 35 patients were operated upon in our unit for subxiphoid hernia prosthetic repair, with a mean age of 59.1 years (SD=13.6).

The demographic characteristics of the patients are shown in Table.

The most common previous surgery was bilateral subcostal laparotomy for a liver transplant (13 cases, 37.1%), followed by 2 cases of hydatid cyst surgery and another 2 for iatrogenic bile. There were 10 cases of sternotomy, 4 for a heart transplant (11.4%), 5 for valve replacement (14.2%) and one case of tetralogy of Fallot. Finally, 8 cases of midline supra-umbilical laparotomy with cephalad extension due to emergency colon occlusion surgery (Hartmann),



The sutures are knotted in a u-shape, and the closure checked. A second PP mesh is inserted, cropped and adjusted to the defect, which is sutured continuously along the edges.

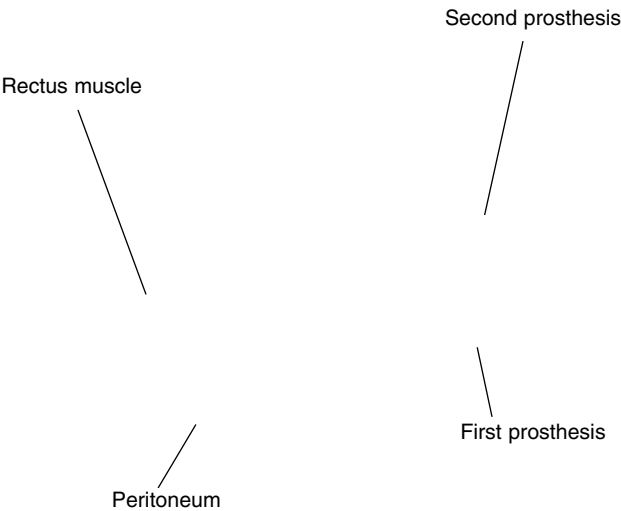
**Figure 4 – Second prosthesis (replacement, in the muscular plane), with size adjusted to the hernia defect.**

adrenalectomy, hemicolectomy and antireflux techniques. There were 5 cases of recurrent tumours (3 of simple suture, and 2 of supra-aponeurotic prosthesis).

Most hernias developed within 2 years of a previous intervention (mean of 15 months, SD=6). Risk factors

associated with its development were surgical wound infection (25.5%) and obesity (43.3%); 17 cases (50%) involved transplants.

Most hernias with a diameter between 2 cm and 5 cm were asymptomatic.<sup>10</sup> All operated patients were ASA II and III.



Sagittal slice of the intervention area: adjusted double mesh.

**Figure 5 – Cross-section of the result.**

**Table 1 – Demographic Data and Univariate Analysis of Factors Involved in Extended Postoperative Hospital Stay.**

|                      | Average Stay ≤6 days (%) | Average Stay >6 days (%) | P    |
|----------------------|--------------------------|--------------------------|------|
| Sex                  |                          |                          |      |
| Male                 | 25 (71.4)                | 6 (17.1)                 | .065 |
| Female               | 3 (8.5)                  | 1 (2.8)                  |      |
| Obesity              |                          |                          |      |
| Thin (BMI<20)        | 1 (2.8)                  | 0                        | .000 |
| Normal (BMI: 20-25)  | 10 (28.5)                | 2 (5.7)                  |      |
| Obese (BMI>25)       | 17 (48.5)                | 5 (14.2)                 |      |
| ASA                  |                          |                          |      |
| II                   | 12 (34.2)                | 4 (11.4)                 | .650 |
| III stable           | 11 (31.4)                | 2 (5.7)                  |      |
| III unstable         | 5 (14.2)                 | 2 (5.7)                  |      |
| Smoker               |                          |                          |      |
| Yes                  | 9 (25.7)                 | 2 (5.7)                  | .091 |
| No                   | 19 (54.2)                | 5 (14.2)                 |      |
| Age                  |                          |                          |      |
| Mean, SD             | 52.9 (14.1)              | 58.6 (14.2)              | .000 |
| ≤50 years            | 8 (22.8)                 | 1 (2.8)                  |      |
| >50 years            | 20 (57.1)                | 6 (17.1)                 |      |
| Diabetes mellitus    |                          |                          |      |
| Yes                  | 4 (11.4)                 | 3 (8.5)                  | .000 |
| No                   | 24 (68.5)                | 4 (28.5)                 |      |
| Immunosuppression    |                          |                          |      |
| Yes                  | 13 (37.1)                | 4 (11.4)                 | .001 |
| No                   | 15 (42.8)                | 3 (8.5)                  |      |
| Surgery time, min    |                          |                          |      |
| Mean, SD             | 97.5 (44.1)              | 98.4 (33.4)              | .070 |
| ≤100                 | 15 (42.8)                | 3 (8.5)                  |      |
| >100                 | 13 (37.1)                | 4 (11.4)                 |      |
| Postoperative seroma |                          |                          |      |
| Yes                  | 5 (14.2)                 | 4 (11.4)                 | .000 |
| No                   | 23 (65.7)                | 3 (8.5)                  |      |

We performed the adjusted double mesh technique on 32 patients (85%), while 3 patients (15%) also underwent modified SAC<sup>11</sup> due to associated subcostal hernias. PP mesh was used in all repairs in the superficial layer. For the retromuscular space, a dual prosthesis was used in 12 cases.

Mean operating time was 98.1 minutes (SD=36.2), which was not significantly related to the mean postoperative hospital stay extension, which was 5.5 days (SD=4), see Table.

There was one case observed of wound infection due to skin ischaemia in a patient who had undergone a transplant and had been operated upon on numerous occasions. This was resolved with cleaning and surgical revision.

A postoperative seroma was found in 17.4% of patients (9 cases), which resolved without drainage. Previous surgical history, the size of the defect, its content or the type of mesh did not influence the occurrence of postoperative seroma or infection. However, the use of fibrin did affect postoperative outcomes: it was used in 23 patients (72%) and was related to a lower rate of postoperative seroma. There were only 3 cases

of seroma observed after application of fibrin, compared with 6 without it ( $P<.001$ ).

The univariate analysis showed that risk factors associated with extended hospital stay ( $P<.001$ ) were: age over 50 years, diabetes mellitus, immunosuppression, BMI over 26 and appearance of postoperative seroma (Table).

All patients in our series were well monitored, with no losses to follow-up and no evidence of recurrence or chronic pain.

## Discussion

Unlike the published series, the previous surgical procedure undergone by most of our patients was abdominal surgery. Although surgeons often extend a mid-incision cephalad, subxiphoid hernias are rare after abdominal surgery. It is believed<sup>3</sup> that the costal-xiphoid ligaments and the transverse muscle of the thorax resist the pulling back of the diaphragmatic fibres inserted centrally, and that the wide

sternotomy with the division of the xiphoid process would increase the lateral forces of the ligaments and muscles, thereby increasing the tension during breathing and coughing, with subsequent dehiscence. In addition, the fascial edges are difficult to identify in the closure of the linea alba. The closure begins to fail at the xiphoid end of the incision due to the division of the lower sternum and xiphoid process.<sup>10</sup> It is suggested that avoiding the bifid xiphoid process and closing the linea alba with nonabsorbable material would prevent the hernia.

Of our patients, 50% had received a transplant and therefore were immunosuppressed, and had additional healing problems.<sup>12</sup> The use of prednisone or sirolimus seemed to be involved in the abdominal wall problems of these patients.<sup>13,14</sup>

Having reviewed the literature, there were few studies with a monograph analysing subxiphoid incisional hernia, and even fewer analyse the treatment for it. The retrospective nature of the series, their small size, heterogeneous population and short follow-up made it difficult to conclude which was the best way to manage these hernias and this has led to some controversy.

Repairing the defect by primary suture means that there is tension at the edges. Although this closure is associated with high rates of recurrence,<sup>3,6</sup> between 43% and 80%, some surgeons see no reason to use a prosthesis in this area.<sup>14</sup> Instead, a modified sternotomy technique<sup>15</sup> to the left paraxiphoid area is proposed, thereby avoiding the division or resection of the xiphoid process, which would reduce the rate of incisional hernias. It is also recommended<sup>11</sup> to improve the distal sternal closure, reinforce it to the end of the xiphoid incision and close the linea alba with a nonabsorbable suture.

In 1985, Cohen and Starling<sup>3</sup> published a subxiphoid hernia repair technique with good results using a high-density PP prosthesis fixed with individual sutures. This technique seemed to be associated with a lower rate of recurrence,<sup>3,5,6,16</sup> between 0% and 32%. The prosthesis can be anchored to the posterior sheath of the rectum muscles and then left exposed on the subcutaneous cell tissue<sup>3</sup> or covered with the external oblique aponeurosis, relaxed through multiple incisions and approximated to the midline,<sup>16</sup> also known as the Clotteau method.

As the upper end of the defect is cartilage and there are technical problems in fixing the prosthesis, the partial or total removal of the xiphoid process is proposed to optimise exposure. Strips of mesh around the rib cage would be a satisfactory anchor point for the prosthesis, although painful,<sup>17</sup> and should be avoided,<sup>18</sup> because the costal perichondrium is richly innervated and its entrapment causes persistent pain.

The literature suggests the retromuscular location as ideal for the prosthesis, which appears to be associated with significant reduction of recurrence.<sup>7</sup> In this location, abdominal pressure holds the prosthesis firmly against the deep surface of the muscle.

When using a prosthesis, it is fundamental to consider its retraction. It is therefore recommended to have at least a 5 cm circumferential overlap, or to use a prosthesis 20% larger

than the defect.<sup>19,20</sup> This is difficult if the fascial defect is close to bony or cartilage structures. Preperitoneal repair in this area requires an adequate cranial overlap. The insertion of the posterior rectus sheath to the xiphoid process acts as a barrier hindering the placement of the mesh. However, it can be removed<sup>18</sup> with proper dissection of the dorsal side of the xiphoid process, opening the retroxiphoid space and inserting the mesh in the retroxiphoid-retromuscular area with adequate margins.

If this space is not obtained, the alternative is supra-aponeurotic repair, which is easier and reproducible. It is easy to place the prosthesis in the subcutaneous layer, as the visibility is good and there is an overlap of 5 cm or more. However, it carries a greater risk of recurrence and the literature<sup>21</sup> suggests that supra-fascial prostheses are associated with increased seroma formation and risk of infection, which cannot be completely eliminated with antibiotics and prophylactic drainage.

The introduction of laparoscopic techniques adds another possibility, although we have no large series or long-term results to endorse its advantages. It began in 2000<sup>22</sup> through bilaminar prosthesis, placed against the inner surface of the defect using four transmural sutures in the corners, and anchored to the posterior rectus sheath around the hernia margins.

A similar attachment system was used in two later series, with recurrence rates of 10%<sup>23</sup> and 33%,<sup>6</sup> respectively, while another brief series of 4 patients<sup>24</sup> reported a postoperative hospital stay of 6.5 days with no recurrence at 6 months.

A mixed form of attachment<sup>25</sup> is recommended with spiral staples around the edges of the prosthesis associated with abdominal transmural sutures of 3 cm-6 cm, as the staples penetrate just 2 cm behind the prosthesis and the tensile strength supported is less than with the combined technique.<sup>26</sup> It is considered sufficient to attach the prosthesis below the rib cage. Staples inserted just under the rib cage, through the chondrocostal junction of the sternum or in the xiphoid process, would improve the closure, but it leads to severe chronic pain. In addition, the placement of staples beyond the chondrocostal margin could lead to serious complications,<sup>27</sup> such as pericarditis or acute cardiac tamponade.

Experience with this method is still limited and does not provide sufficient data on the effect of the prosthetic material anchored to the diaphragm on respiratory physiology. In proximal hernias, attaching the prosthesis to overlap the defect by 5 cm would need transdiaphragmatic-parasternal sutures, which would alter diaphragmatic mobility.<sup>18</sup> It is generally accepted that the cephalic portion of the prosthesis is not fixed,<sup>24</sup> as the abdominal pressure extends and fixes the mesh, adding strength to the repair. In addition, the left lobe of the liver and stomach keep this region relatively protected.

Our unit considered the subxiphoid incisional hernia as a separate entity,<sup>2</sup> and has prepared a repair protocol using the technique described, which is original as far as we know. We have shared our technique in meetings and workshops without encountering similar experiences. Our hospital, with liver and cardiac transplant units, has these incisional hernias. On the negative side, the fact of being a reference group means that we take patients who live far from the

hospital, which prevents early discharge or management by home care units, which would shorten hospital stay.

When we prepared the procedure, we wanted to combine several principles that we considered essential:

- 1) The closure must be performed with tension-free suture.<sup>28</sup> The relationship of this with recurrence due to failure at the edges, which are ischaemic due to traction, is well known. With tension, it is better not to close the defect, but to replace it with a prosthesis.
- 2) Deep placement of the prosthesis, in the preperitoneal space, is the option advocated by several authors,<sup>7,29,30</sup> attributing better outcomes in the treatment of other incisional hernias.
- 3) Use of a double prosthesis. A premise described by Condon<sup>31</sup>: if the edges cannot be brought together because of tension, the planes are dissected at least 6 cm around the rim of the defect, and a piece of synthetic material is placed on each plane: preperitoneal and supra-aponeurotic. The prostheses allow repair without modifying the local tissue, preventing muscle plasties and muscle-aponeurotic splits (with associated time and complications problems). Moreover, they decrease tension and prevent relapses. One review<sup>32</sup> concluded that recurrence is reduced if a double mesh is used. The technique has been performed in both the open<sup>33,34</sup> and combined<sup>35</sup> approaches (laparoscopy and anterior).
- 4) Finally, according to the findings of Amid,<sup>36</sup> with wound healing a PP prosthesis may retract by up to 20%. Therefore, adjusting the mesh replacement to the defect, which is not closed to reduce tension, means that fibroblast wound healing invasion would reduce the prosthesis, gradually closing the defect and providing a firm closure, like a strong seal. In addition, a lower prosthesis should not be too tight to prevent tension and an uncomfortable feeling of tightness.

Our ultimate goal is to introduce a technique to CIRUGÍA ESPAÑOLA which has excellent results in our hands, both from our point of view (ease of performance and reproducibility) and that of the patient (comfort, early discharge from hospital and return to daily life). In addition it has a low complication rate, despite having patients with comorbidity. To date, there have been no recurrences, although we are aware that one always must be cautious when making such a statement.

## Conflict of Interest

The authors affirm they have no conflict of interest.

## REFERENCES

1. Hoer J, Lawong G, Klinge U, Schumpelick V. Factors influencing the development of incisional hernia. A retrospective study of 2,983 laparotomy patients over a period of 10 years. *Chirurg*. 2002;73:474-80.
2. Muysoms FE, Miserez M, Berrevoet F, Campanelli G, Champault G, Chelala E, et al. Classification of primary and incisional abdominal wall hernias. *Hernia*. 2009;13:407-14.
3. Cohen MJ, Starling JR. Repair of subxiphoid incisional hernias with Marlex mesh after median sternotomy. *Arch Surg*. 1985;120:1270-1.
4. Davidson BR, Bailey JS. Incisional hernia following median sternotomy incisions: their incidence and aetiology. *Br J Surg*. 1986;73:995-6.
5. Davidson BR, Bailey JS. Repair of incisional hernia after median sternotomy. *Thorax*. 1987;42:549-50.
6. Mackey RA, Brody FJ, Berber E, Chand B, Henderson JM. Subxiphoid incisional hernias after median sternotomy. *J Am Coll Surg*. 2005;201:71-6.
7. Schumpelick V, Junge K, Rosch R, Klinge U, Stumpf M. Retromuscular mesh repair for ventral incision hernia in Germany. *Chirurg*. 2002;73:888-94.
8. Tanaka EY. A computerized tomography scan method for calculating the hernia sac and the cavity volume in complex large incisional hernia with loss of domain. *Hernia*. 2010;14:63-9.
9. Fernández Lobato R, Martínez Santos C, Ruiz de Adara JC, Fradejas JM, Ortega P, Moreno Azcoitia M. Aplicación del adhesivo de fibrina Tissucol® en eventraciones complejas. *Cir Esp*. 2002;71:80-4.
10. Losanoff JE, Basson MD, Laker S, Weiner M, Webber JD, Gruber SA. Subxiphoid incisional hernias after median sternotomy. *Hernia*. 2007;11:473-9.
11. Carbonell Tatay F, Bonafé Diana S, García Pastor P, Gómez Gavara C, Baquero Valdelomar R. Nuevo método de operar en la eventración compleja: separación anatómica de componentes con prótesis y nuevas inserciones musculares. *Cir Esp*. 2009;86:87-93.
12. Piardi T, Audet M, Panaro F, Gheza M, Cag N, Portolani J, et al. Incisional hernia repair after liver transplantation: the role of the mesh. *Transplant Proc*. 2010;42:1244-7.
13. Jansen H, Lange R, Erhard J, Malago M, Eigler FW, Broelsch CE. Causative factors, surgical treatment and outcome of incisional hernia after liver transplantation. *Br J Surg*. 2002;89:1049-54.
14. Read RC, Yoder G. Recent trends in the management of incisional herniation. *Arch Surg*. 1989;124:485-8.
15. Barner HB. A technical modification of median sternotomy to eliminate subxiphoid incisional hernias. *Arch Surg*. 1987;122:843.
16. Bouillot JL, Badawy A, Alexandre JH. Incisional abdominal hernia after median sternotomy. Repair with the use of Dacron mesh. *Hernia*. 1997;1:129-30.
17. Merrell RC, Than-Trong T. Osseous and Chondral fixation of polypropylene mesh. *Am J Surg*. 1985;149:816-8.
18. Conze J, Prescher A, Kisielinski K, Klinge U, Schumpelick V. Technical consideration for subxiphoid incisional hernia repair. *Hernia*. 2005;9:84-7.
19. Amid PK. The Lichtenstein repair in 2002: an overview of causes of recurrence after Lichtenstein tension-free hernioplasty. *Hernia*. 2003;7:13-6.
20. Freund HR, Charuzi I. Laparoscopic and open repair of post-sternotomy incisional hernia of the subxiphoid region. In: Morales-Conde S, editor. *Laparoscopic ventral hernia repair*. Paris: Springer; 2003. p. 375-82.
21. White TJ, Santos MC, Thompson JS. Factors affecting wound complications in repair of ventral hernias. *Am Surg*. 1998;64:276-80.
22. Muscarella P, Needleman BJ, Goldstein AH, Steinberg SM. Laparoscopic repair of a subxiphoid incisional hernia following median sternotomy. *Surg Rounds*. 2000;23: 605-11.



23. Landau O, Raziel A, Matz A, Kyzer S, Haruzi I. Laparoscopic repair of poststernotomy subxiphoid epigastric hernia. *Surg Endosc.* 2001;15:1313-4.
24. Eisenberg D, Popescu WM, Duffy AJ, Bell RL. Laparoscopic treatment of subxiphoid incisional hernias in cardiac transplant patients. *JLS.* 2008;12:262-6.
25. Ramshaw BJ, Esartia P, Schwab J, Mason EM, Wilson RA, Duncan TD, et al. Comparison of laparoscopic and open ventral herniorrhaphy. *Am Surg.* 1999;65:827-31.
26. Heniford BT, Park A, Ramshaw BJ, Voeller G. Laparoscopic repair of ventral hernias: nine years' experience with 850 consecutive hernias. *Ann Surg.* 2003;238:391-400.
27. Park A, Heniford BT, LeBlanc KA, Voeller GR. Laparoscopic repair of incisional hernias. Part 2: surgical technique. *Contemp Surg.* 2001;57:225-38.
28. Lichtenstein IL, Shulman AG, Amid PK, Monitor MM. The tension-free hernioplasty. *Am J Surg.* 1989;157:188-93.
29. Awad ZT, Miedema B. Subxiphoid incisional hernias after median sternotomy. *J Am Coll Surg.* 2006;202:386-7. Author reply 387.
30. Martín-Duce A, Nogueras F, Lozano O, Villeta R, Martín J, Mugüerza J, Díez M. Treatment of lateral incisional hernias. *Eur J Surg.* 1999;165:1187-8.
31. Condon RE. Incisional hernia. In: Nyhus LM, Condon RE, editors. *Hernia*. Philadelphia: JB Lippincott Company; 1995. p. 319-36.
32. Awad ZT, Puri V, LeBlanc K, Stoppa R, Fitzgibbons RJ, Iqbal A, et al. Mechanisms of ventral hernia recurrency after mesh repair and a new proposed classification. *J Am Coll Surg.* 2005;201:132-40.
33. Moreno Egea A, Torralba JA, Morales G, Aguayo JL. Reformulación conceptual de la técnica de reparación doble: una solución sencilla para defectos muy complejos de la pared abdominal. *Cir Esp.* 2006;80:101-4.
34. Moreno Egea A, Mengual M, Cases MJ, Aguayo JL. Repair of complex incisional hernias using double prosthetic repair: single-surgeon experience with 50 cases. *Surgery.* 2010;48:140-4.
35. Treviño JM, Franklin ME, Berghoff KR, Glas JL, Jaramillo EJ. Preliminary results of a two layered prosthetic repair for recurrent inguinal and ventral hernias combining open and laparoscopic techniques. *Hernia.* 2006;10: 253-7.
36. Amid PK. Classification of biomaterials and their complications in abdominal wall hernia surgery. *Hernia.* 1997;1:15-21.