Journal MVZ Cordoba
2021; May-August. 26(2):e1867.
https://doi.org/10.21897/rmvz.1867

Original

Umbilical herniorrhaphy with polyvinyl chloride (PVC) in pigs (*sus scrofa domesticus*): pilot study

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Received: January 2020; Accepted: February 2021; Published: May 2021.

ABSTRACT

Objective. To evaluate the clinical effectiveness of PVC on umbilical herniorrhaphy in pigs. **Materials and methods.** We used 16 clinically healthy pigs of both sexes, aged between 2 and 3 months, Landrace and Landrace x Pietran breeds with an average weight of 20 kg. Inclusion criteria were based on the clinical diagnosis of umbilical hernia. Herniorrhaphy was carried using PVC as a prosthetic material. The implantation of the material was made between parietal peritoneum and abdominal muscles by creating a pocket in 360°, with a depth of five centimeters. For the fixation of the bag, 35 pounds of pressure polyamide was used with "U" points in the fascio-muscular package (four stitches overall), the knots were two centimeters next to the ring, avoiding inverted edges with sustained traction. The size of the PVC bag depended on the size of the ring, but it was constantly rounded and four centimeters larger than the edge of the ring. The parameters evaluated for 15 days were temperature, edema, wound color and dehiscence, and relapse, fistula and appetite for 2 months. **Results.** An average local temperature of 37.5°C was obtained. Tumor halos of one centimeter at 24 hours post-surgery with involution towards the end of the evaluation. 100% of the animals healed by first intention. 87.5% did not present recurrence of the hernia. 100% did not present signs compatible with fistula or granuloma. Appetite was normal. **Conclusions**. During the evaluation period, PVC proved to be effective in the correction of umbilical hernias in pigs.

Keywords: Biomaterial; polyvinyl chloride; hernia; umbilical (*Source: MeSH*).

RESUMEN

Objetivo. Evaluar clínicamente la efectividad del PVC en herniorrafias umbilicales en cerdos. **Materiales y métodos.** Se utilizaron 16 cerdos clínicamente sanos, de ambos sexos, con edades entre dos y tres meses, de las razas Landrace y Landrace x Pietran y peso promedio de 20 kilogramos. La inclusión se basó en el diagnóstico clínico de hernia umbilical. A todos se les implantó PVC como material protésico entre peritoneo parietal y músculos abdominales. Para la fijación de la bolsa se utilizó poliamida de 20 libras de presión con puntos en "U" (cuatro en total), quedando los nudos

How to cite (Vancouver).
Martínez MM, Avendaño PE, Pérez BD. Umbilical herniorrhaphy with polyvinyl chloride (PVC) in pigs (*sus scrofa domesticus*): pilot study. Rev MVZ Cordoba. 2021; 26(2):e1867. https://doi.org/10.21897/rmvz.1867

ISSNL: 0122-0268

a dos centímetros del anillo y evitando con la tracción la formación de pliegues invertidos. El diámetro de la bolsa de PVC dependió del diámetro del anillo herniario, pero con la constante que fuese redondeada y cuatro centímetros mayores. Parámetros como temperatura, edema, color y dehiscencia de la herida se evaluaron por 15 días, mientras que recidiva de la hernia, fistulación y apetito se evaluaron por dos meses. **Resultados.** Se obtuvo un promedio de temperatura local de 37.5°C. Halos tumorales con medidas de un centímetro a las 24 horas post-quirúrgico con involución hacia el final de la evaluación. El 100% de los animales cicatrizó por primera intención. El 87.5% no presentó recidiva de la hernia. El 100% no presentó signos compatibles con fístula o granuloma y el apetito fue normal. **Conclusiones.** Durante el periodo de evaluación, el PVC demostró ser efectivo en la corrección de hernias umbilicales en cerdos.

Palabras clave: Biomaterial; cloruro de polivinilo; hernia; umbilical (*Fuente: MeSH*).

INTRODUCTION

Surgery with pigs as patients isn't always positive from the cost/benefit point of view. Some frequent conditions such as hernia, prolapse, dystocia and atresia can be wasteful for the industry (1), with an estimated cost in materials and professional service, specialized in correction of umbilical hernia in 20kg pigs, rounding at 100 dollars (see author's note).

Umbilical hernia are among the pathologies of frequent presentation with varied etiology, such as: genetics, congenital defects, umbilical infections, tissular weakness and animal management. According to one study in congenital malformations in this species, it was found that inguino-scrotal and umbilical hernias represent, respectively, 12.9% and 45.2% of congenital pathologies (2).

Umbilical hernia is one variant of ventral hernias in domestic animals, characterized by the emergence of viscera from the peritoneal cavity throughout the umbilical ring, being the small intestine its main content. The diagnostic is clinical, and in most cases, palpation favors the reintroduction of the hernial cavity (reducible hernia). There is a small percentage (non-reducible hernias) where diagnostic helps such as ultrasounds and/or radiology are used to confirm the diagnosis; but they are seldom used in pigs for cost reasons (3).

Although there are diverse surgical techniques for hernia corrections, there isn't one that is widely accepted as the best by surgeons. Because of this, there is always a search for new methods that fulfill all expectations when it comes to doing a herniorraphy (3).

Correction techniques are classified as techniques with tension and techniques without tension. The last ones are characterized use nets made of diverse materials that can be non-absorbable or mixed; synthetic or natural (such as fascia or biologic membranes), implanted over the abdominal aponeurosis, between the aponeurosis and the abdominal muscles, between the muscles and the parietal peritoneum, or intraperitoneal (3).

When it comes to the biomaterials, they must round up a series of conditions, such as: easy acquisition, cheap, easy to sterilize, don't require specialized instruments, non-carcinogen, non-allergen and overall, they must be tolerated in the implantation local (3). PVC has important traits as a prosthetic material like sterilization possibility, inert, easy to manipulate, availability and low cost (4).

PVC is a polymer derived from polyvinyl chloride, widely used due to its inherent proprieties such as resistance to abrasion and impact, its light weight, waterproof, chemically and biologically inert, durable, and resistant to fire, it doesn't burn unless it's in the presence of continuous flames. With the use of additives such as stabilizers, plasticizers or others, PVC resin transforms into a rigid or flexible material, that allows for a wide variety of uses in many areas such as construction, packaging, mobiliary, electrical industry, automobile industry, medical applications, farming, and others (4). The objective of this research was to clinically evaluate the effectiveness of PVC in umbilical herniorraphy in Landrace and Landrace x Pietran pigs.

MATERIALS AND METHODS

Type of study. Descriptive.

Type of sampling and calculation of sample size. For this study there was a non-probabilistic type of sampling, made by intention, since for technical and economic reasons there wasn't a larger number of animals available.

Ethical aspects. The methodology of this work was approved by the Ethics Committee of the Veterinary Medicine and Zootechnics Faculty from the University of Cordoba, according to record N° 004 from September 3 of 2010, taking into account the technical norms for the use of animals for experimentation, framed in the fulfillment of the "Universal Declaration for Animal Rights", of the "International Norms for Biomedical Research with Animals", established by the World Health Organization, Law 84 of October 1989 of the Health Ministry in Colombia and Law 1774 of January 6 of 2016 of the Penal Codex in the country of Colombia.

Localization. The research was done in the veterinary clinic Julio E. Cuervo, belonging to the Veterinary Medicine and Zootechnics Faculty from the University of Cordoba, Colombia, located in the Berástegui campus in Ciénaga de Oro-Córdoba.

Patients. 16 pigs of both sexes aged between 2 and 3 months, Landrace and Landrace x Pietran breeds with an average weight of 20 kilograms were used. Inclusion criteria was based on the clinical diagnosis of umbilical hernia. During the study they were kept in herds with food given to them twice a day and water at disposal. The animals were provided by the porcine reproductive program of the Veterinary Medicine and Zootechnics Faculty.

Methods and instruments for data picking. There were blood samples done to the patients to have an idea of their general state of health. During the post-operatory period of 15 days, parameters such as temperature, umbilical region edema and color, dehiscence of the wound, hernia relapse, fistula and animal appetite were evaluated. For the interpretation of collected data the tendency line was used as statistical measure.

Used materials. The implanted PVC was obtained from bags fabricated to contain solutions for fluid therapy. The first wrapping bag was discarded, exclusively using for the research the recipient bag for the liquid, which comes sterilized according to the fabricant (Fresenius Kabi Colombia S.A.S).

Pre-surgical. The patients were submitted to solid fasting for 24 hours with permanent access to water. In the anatomical zones involved in the procedure, an antisepsis routine was technically recommended with povidone iodine, with a previous washing with water and soap. As anesthetic protocol, azaperone (3 mg/kg intramuscular) and propofol (10 mg/kg intravenous) were used as pre-anesthetic and inductor, respectively. The anesthetic maintenance was reached with isoflurane at 3% (5). For the drug application and hydration, they were previously funneled through the marginal auricular vein with a continuous drip of 20 drops/minute of Ringer lactate.

Surgical approach description. The surgical technique used was based on the Rives-Stoppa technique, who implanted a net in the pre-peritoneal space (6), which was chosen to place the PVC bag, described below:

An elliptical incision was done on the skin, centered around the external hernial sack, which was completely debrided (Figure 1A). Next, a divulsion of the subcutaneous cellular tissue was done with a finger wrapped in gauze until reaching the base of the hernial ring, which freed the internal hernial sack that was introduced to the abdominal cavity digitally or with dissection forceps, which eased the identification of the hernial ring (Figures 1B and 1C). Immediately after, the abdominal fascia was incided at a 360° angle, one millimeter away from the edge of the hernial ring (Figure 1D) to detach the internal hernial sack from its muscular adherence digitally or with a Mayo scissor and create a pocket with a maximum depth of five centimeters independent from the ring diameter (Figures 2A and 2B).

The size of the implanted PVC depended on the size of the ring (Figures 2C and 2D), the bag was cut in a round shape with a size of four centimeters wider than the diameter of the ring. It was placed with four "U"-shaped stitches at 9:00, 3:00, 6:00 and 12:00, according to the clock hands. The used suture was 35 pounds of pressure polyamide (Figure 3A).

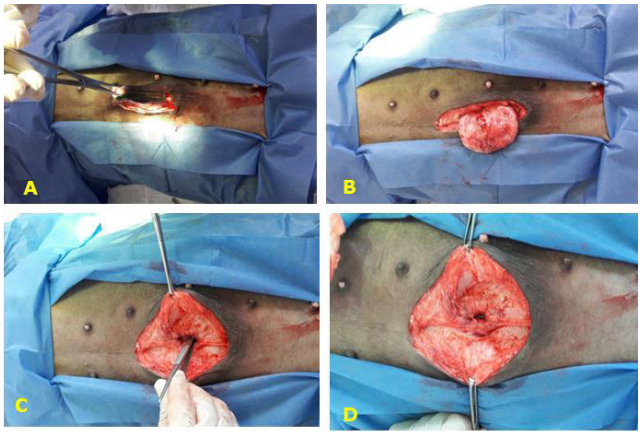

Figure 1. A) Cutaneous incision. B) Internal hernial sack divulsion. C) Introduction of the peritoneal sack and identification of the hernial ring edges. D) Incision of the abdominal fascia, one mm away from the hernial ring edge.

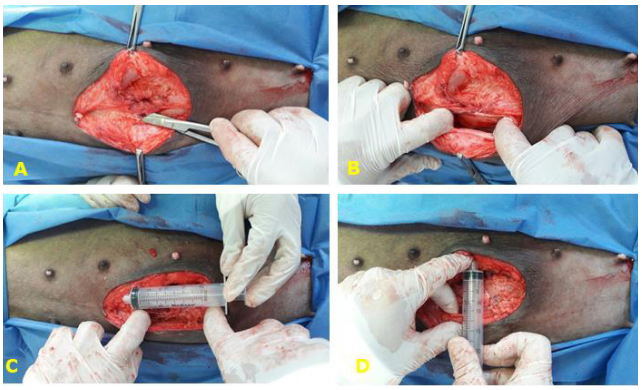

Figure 2. A) Beginning of the divulsion of the peritoneal sack with a Mayo scissor. B) Continuation of the divulsion with fingers. C) Longitudinal measurement of the hernial ring. D) Transversal measurement of the hernial ring.

To ease the path of the polyamide through the abdominal fascia and muscles, the researchers designed an U-shaped needle with a buttonhole in each tip. The first two stitches were placed cranial and caudal to the ring (9:00 and 3:00) (Figure 3B), followed by the two lateral stitches (12:00 and 6:00). The knots were placed two centimeters apart from the edge of the ring. To stop the PVC bag from getting inverted folds, sustained traction of the threads was done, while also taking the chance to adjust them (Figure 3C).

Once the PVC bag was implanted in the pre-peritoneal space, it was sutured with polyglactin 910 caliber 2-0 and simple continuous stitch through the edges of the fascio-muscular fold, with sustained and light tension without reaching the touching of the edges (Figure 3D). This step helped to reduce the dead space. The remaining planes were sutured in routine manner.

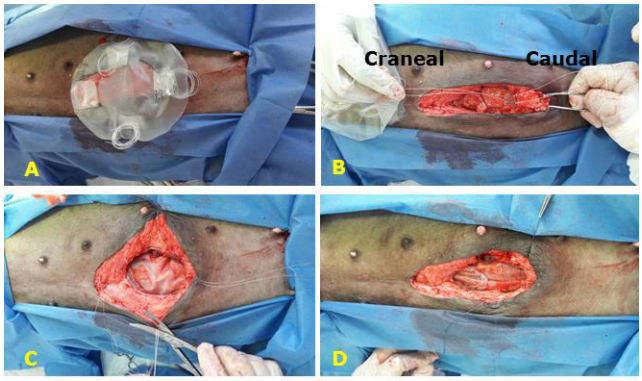

Figure 3. A) Casting of the PVC bag and placing of the "U"-shaped stitches. B) Insertion of the "U"-shaped needle for the passage of the thread edge. C) Suturing and cutting of the polyamide edges. D) Placing of the PVC bag in the pre-peritoneal space.

Post-surgical. For antibiotic therapy, a single dose of oxitetracicline L.A of 20 mg/kg intramuscular was used, and for anti-inflammatory therapy, a dose of betamethasone of 2 mg/kg intramuscular for 3 days. In this period, temperature of the surgical location, edema, are color and wound dehiscence were evaluated for 15 days, while hernia relapse, fistula and animal appetite were evaluated for two months. To measure the temperature a digital infrared thermometer from the label Non-contact IR was used (Guangzhou Kyunion Co.Ltd.).

RESULTS

Temperature of the surgical location. From the evaluation of the temperature in the anatomic-surgical location a mean of 37.5°C was obtained in all patients. Observing Figure %, it can be said that towards the fourth day the temperature reached its maximum (38.2°C) with a tendency of normalcy the following days.

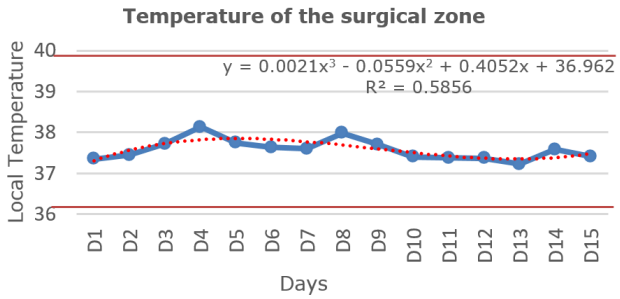

Figure 4. Graphic representation of the tendency line of cutaneous temperature in the surgically intervened zone, clinically evaluated during the 15 days of post-operatory.

The temperature tendency followed a polynomic behavior of third order in relation to time, explained by the following linear equation:

$y = 0.0021x^3 - 0.0559x2 + 0.4052x + 36.962$ ($R^2 = 0.5856$)

Where:
y= Temperature of the anatomic-surgical zone.
x= Units in days

The determination coefficient pointed that this behavior is explained in a 58% by the previous linear equation.

Edema. The animals showed a significant decrease of the inflammation that came with the tissue manipulation and implantation of the PVC, with tumor halos of one centimeter after 24 hours of the surgery and some patients without presence of it, getting a classification of 1 and 0, respectively. Moreover; it can be inferred that the tendency of the edema was to regress, reaching complete normalcy by the end of the evaluation (Figure 5).

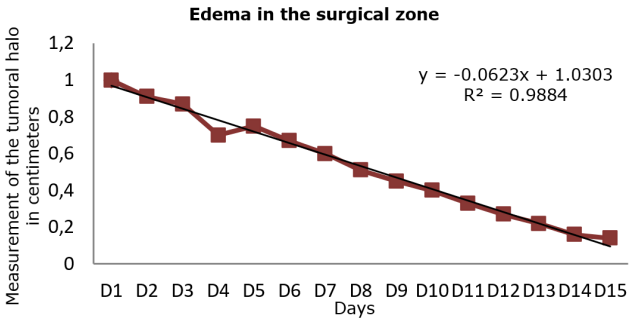

Figure 5. Tendency line of tumor halo during the 15 days of post-operatory evaluation.

The tendency of the tumor halo followed a decreasing linear behavior in function of time, explained by the following linear equation

$y = -0.0623x + 1.0303$ ($R^2 = 0.9884$)

Where:
y = Measurement in centimeters of tumor halo
x = Units in days

The determination coefficient pointed that this behavior is explained in a 98% by the previous linear equation.

Surgical location color. 100% of the animals, during the first seven days, presented flushing of the wound zone, placing in a classification of 1, and from the eight day until the end of the evaluation they tended to normalcy, classifying as grade 0 (Figure 6).

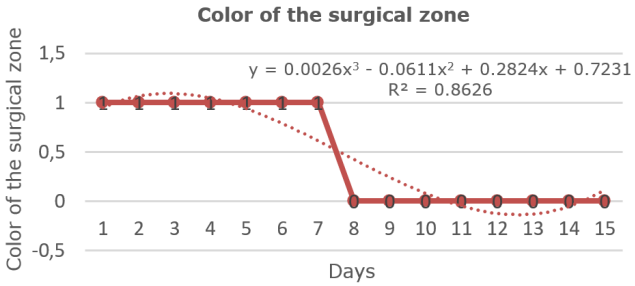

Figure 6. Tendency line of color of the surgical location, clinically evaluated for 15 days of post-operatory.

The tendency of color followed a polynomic behavior of third order in function of time, explained by the following linear equation:

$y = 0.0026x^3 - 0.0611x2 + 0.2824x + 0.7231$ ($R^2 = 0.8626$)

Where:
y= Color of surgical zone (1 flushed and 0 normal)
x= Units in days

The determination coefficient pointed that this behavior is explained in a 86% by the previous linear equation.

Temperature of the surgical location. From the evaluation of the temperature in the anatomic-surgical location a mean of 37.5°C was obtained in all patients. Observing Figure %, it can be said that towards the fourth day the temperature reached its maximum (38.2°C) with a tendency of normalcy the following days (Figure 7).

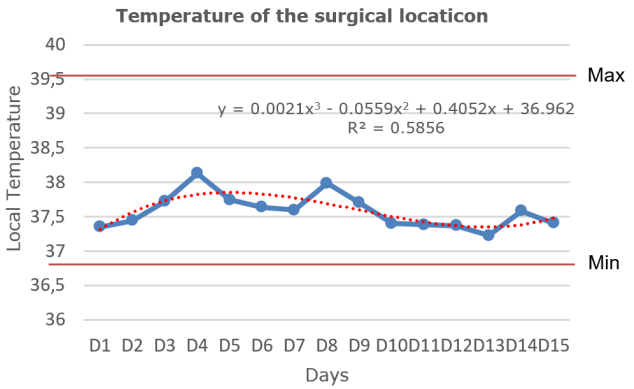

Figura 7. Tendency line of cutaneous temperature in the surgically intervened zone, clinically evaluated during the 15 days of post-operatory.

The cutaneous temperature tendency followed a polynomic behavior of third order in relation to time, explained by the following linear equation:

$y = 0.0021x^3 - 0.0559x2 + 0.4052x + 36.962$ ($R^2 = 0.5856$)

Where:
y= Temperature of the anatomic-surgical zone.
x= Units in days

The determination coefficient pointed that this behavior is explained in a 58% by the previous linear equation.

Wound dehiscence. When it came to evaluating the process of closing and scarring of the wound, 100% of the animals evolved favorably, classifying at grade 0 (absent) according to the classification of Martínez et al (3).

Hernia relapse. Out of all assessed animals, it was found that 14 (87.5%) did not present hernia relapse, placing in classification 0, and 2 (12.5%) presented relapse, placing in classification 1 according to the classification of Martínez et al (3).

Fistulation. 100% of animals did not show clinical signs compatibles with this condition, having a favorable closing of the wound and the scarring process.

Appetite and weight gain. 100% of animals showed normal appetite behavior, placing in classification 1. This variable was reflected in the weight gain of the pigs, which was of 0.686 kg/day, calculated with the following equation (7, 8):

Mean weight gain=(FINAL WEIGHT-INITIAL WEIGHT)/(DAYS)

The tendency of the post-operatory weight gain (Figure 8) followed an exponential behavior in relation to time, as it is shown in the following linear equation:

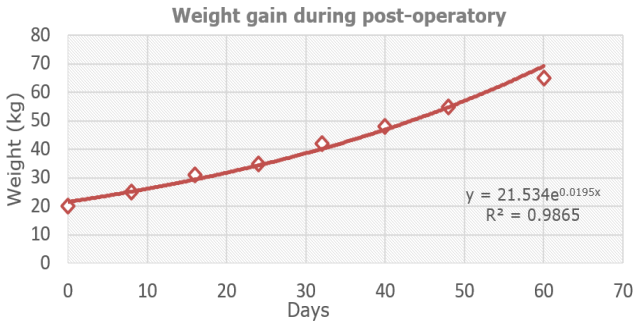

Figure 8. Tendency line of daily weight gain during post-operatory.

$y = 21.534e^{0,0195x}$ ($R^2 = 0.9865$)

Where:
y= Weight in kilograms.
x= Units in days

The determination coefficient pointed that this behavior is explained in a 98% by the previous exponential equation.

DISCUSION

Post-surgical evaluation. The surgically intervened animals with the implantation of PVC for the correction of umbilical hernias didn't present any post-operatory complications, such as chronic edema or flushing. The results are similar to those reported using the Mayo technique, with implantation of autogenous abdominal fascia and using a compound of latex, polyamide and 0.1% polylisine (2,3,9).

The temperature of the anatomical-surgical placement had a behavior inside the physiological normalcy. Furthermore; it can be inferred that the implanted material between the parietal peritoneum and the abdominal muscles didn't cause infection or an inflammatory reaction beyond the physiological limits, such as the ones reported in case reports with net implants used

to correct umbilical hernias in humans, in which infections are between 0.13–0.58, CI=95% (10,11).

Edema. The inflammatory process occurred in physiological conditions; the first day of evaluation revealed an increase of one centimeter, regressing in time until reaching normalcy at day 15. The results are similar to those reported by other authors, in which they affirm that the inflammatory stage begins at 16 minutes and can last up to six days (12,13,14). This cardinal sign of inflammation happens due to vascular and cellular response, stimulated by chemokines such as: histamine type I, complement-derived factors (C3a and C5a), prostaglandins and nitric oxide, which increase capillary permeability for the diapedesis, with the subsequent formation of edema (12,13,14).

Wound dehiscence. It was absent, differing from the results of other works that use self-insert bovine abdominal fascia and synthetic netting that report a wound dehiscence between 30 and 60% in assessed patients, intense skin and subcutaneous edema being a constant trait (3,14).

Hernia relapse. Two animals (12.5%) presented a relapse, that could have been due to colagenase activity in the tissues with active inflammatory processes, making the collagen unfold and negatively influence its synthesis, reflected in the lower tissue resistance to tension (11,12,13), like it happens with abdominal contents over the surgical location, thus favoring the appearance of relapse. This relapse percentage was similar to that of 10.4% reported in eventrations corrections with the Rives-Stoppa technique in humans (14). Moreover; it is worth noting that the behavior of pigs to resist when it came to healing, plus the fact that the animals included in the study did not have dietary restrictions, could be variables that influenced the relapse. The results of the study differ from another report that didn't have complications (3) and matches the reports of 5 to 10% of relapse in herniorraphies with prosthetic netting in humans (6).

In this study, the PVC implantation as prosthetic material for herniorraphies showed an effectiveness of 87.5%. It must be said that the animals that relapsed were the ones with higher temper and the suturing stitches were found broken. The PVC tear was confirmed post-discard in the animals. The results agree with other studies that report tearing of the material in 67% and 83% when it was used as a prosthesis in the management of open abdomen in humans (4).

Fistulation. Although no tests were done to evaluate the biocompatibility of the PVC and polyamide used to suture and set the prosthetic material to the abdominal fascia, it is presumed that they were accepted by the receiving tissue since there was no clinical evidence of fistulous processes or granulomas, matching with other reports (6,15).

Weight gain. The food intake in the animals was normal, with a mean daily weight gain of 686 gr/day (Figure 8), which allows to presume that corrective surgery with a PVC bag does not affect pig behavior, since their food conversion parameters occurred between the pre-established ranges in the management of this species, which is 659±193 gr/day (16).

In conclusion, the results of the present study can conclude that herniorraphy in pigs with a modified Rives-Stoppa technique using PVC as a net was effective; with advantages such as low relapse, null fistula presence, no adherences or granulomas, short convalescence of the animals (from seven to 10 days), low cost of the material and easy acquisition. The intervened patients kept their appetite, which guaranteed a weight gain in accord to the productive phase. For all of the previous reasons, its use it's recommended in the porcine production programs.

Conflict of interest

The authors declare they have no conflicts of interest with regard to the work presented.

Acknowledgment

The authors would like to thank the Veterinary Medicine and Zootechnics Faculty from the University of Cordoba, Colombia, for the logistic and economic support.

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