

Pediced gallbladder flap as a repair technique of duodenal injuries

Colgajo pediculado de la vesícula biliar como técnica de reparación de lesiones duodenales

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Palabras clave:

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ABSTRACT

Objective: To determine the efficacy of a pediced gallbladder flap for the correction of duodenal lesions. **Material and methods:** Six pigs weighing between 20 and 30 kg were operated on. Under general intravenous anesthesia, a linear and longitudinal incision of five centimeters in length was made in the anterior face between the first and second portion of the duodenum with a scalpel blade no. 15. The gallbladder was separated from the hepatic bed, the cystic duct was ligated, the vasculature (cystic artery) was preserved and the gallbladder flap with its artery was mobilized to the site of injury in the duodenum. **Results:** The pediced flap of the gallbladder was successfully performed in six pigs; five of them tolerated initial postoperative diet at 24 hours, one pig at 48 hours; all of them had bowel movements before 48 hours. No surgical wound infection data were found; there was no information suggestive of intestinal leakage, acute abdomen or systemic inflammatory response syndrome. None of the slaughtered pigs showed macroscopic leakage data. On histopathological examination, we observed complete adhesion of the vesicular patch in the lesions. **Conclusions:** The repair of duodenal defects can be performed by a gallbladder flap with its pedicle sutured to the edges of the defect.

RESUMEN

Objetivo: Determinar la eficacia de un colgajo pediculado de la vesícula biliar para reparar lesiones duodenales. **Material y métodos:** Se intervinieron seis cerdos de entre 20 y 30 kg de peso. Bajo anestesia general endovenosa, se realizó una incisión lineal y longitudinal de cinco centímetros en la cara anterior entre la primera y segunda porción del duodeno con una hoja de bisturí núm. 15. Se separó la vesícula biliar del lecho hepático, se ligó el conducto cístico, se conservó la vasculatura (arteria cística) y se movilizó el colgajo de la vesícula biliar con su arteria hasta el sitio de la lesión en el duodeno. **Resultados:** Se realizó de manera satisfactoria el colgajo pediculado de la vesícula biliar en seis cerdos; cinco de ellos toleraron la dieta inicial postoperatoria a las 24 horas, y uno hasta las 48 horas; todos presentaron evacuaciones antes de las 48 horas. No se encontraron datos de infección de la herida quirúrgica ni datos sugerentes de fuga intestinal, abdomen agudo o respuesta inflamatoria sistémica. Ninguno de los cerdos sacrificados mostró datos de fuga macroscópica. Histopatológicamente, se observó una adhesión completa del parche vesicular en las lesiones. **Conclusiones:** La reparación de los defectos duodenales puede lograrse mediante un colgajo de la vesícula biliar junto a su pedículo suturado a los bordes del defecto.

INTRODUCTION

Duodenal injuries are infrequent, but they cause an alarming morbidity and mortality rate, which is why their recognition and early treatment is essential.^{1,2} The incidence of

duodenal injuries is between 3.7 and 5%.³ Watts et al.⁴ calculated the prevalence of blunt trauma to hollow viscera and they found a total of 227,972 due to blunt trauma. 2,632 were lesions of hollow viscera. Among these injuries, the duodenum was the fourth most involved

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organ, in 12% of cases; the second portion was the most affected. Very often, it is associated with other types of injuries to surrounding organs, of which the most frequently involved is the liver.⁵ The main complications of duodenal trauma are fistula formation and duodenal stenosis. The mortality rate varies between 5.3% and 30%, with an average of 17%.⁶

It is important to have a broad knowledge of the anatomy of this organ (especially when classifying these lesions), as well as the mechanism that produces the injury during the diagnostic approach of duodenal trauma. The intimate relationship of associated injuries should not be overlooked, which, if present, darkens the prognosis, since the duodenum is related with other retroperitoneal organs and large vascular structures that can imminently endanger the patient's life.

No benefit has been found in the use of laparoscopy compared to conventional diagnostic methods in the evaluation of the duodenum. As a last resort for diagnosis, when the suspicion or duodenal injury has not been completely ruled out, exploratory laparotomy is performed.^{2,7-9}

Duodenal trauma poses a challenge for the surgeon, failure in management translates into fatal results. The golden rule in the duodenal trauma approach is early diagnosis and immediate surgical treatment, with damage control and selective repair depending on the type of injury.¹⁰

There is an important variety of surgical techniques for the repair of duodenal injuries, which are practiced depending on the magnitude of the injury and its location (*Table 1*). There is no consensus in their management, which results in lack of effectiveness.¹¹⁻¹⁵ The object of the current study was to put into practice an innovative technique based on anatomical, physiological and general surgery principles, placing a flapped gallbladder pedicle for the repair of any type of duodenal injury; especially in the case of complex ones.

MATERIAL AND METHODS

The analysis of the graduate thesis for the degree of General Surgery entitled "Viability of the pedicled gallbladder flap as part of the

repair of duodenal injuries" and systematic review with an update of the literature were carried out at the Central State Hospital in the city of Chihuahua in 2012.

An experimental study in an animal model was carried out in the Surgical Techniques Laboratory of the Faculty of Medicine, UACH, involving six pigs weighing between 20 and 30 kg. General intravenous anesthesia with Zoletil® 50 (tiletamine hydrochloride 125 mg and zolazepam hydrochloride 125 mg), was administered at a rate of 0.1 mL/kg intramuscularly as an induction dose; then, it was administered intravenously (via the ear) as a maintenance dose. A 10 cm Kocher-type incision was made, properly exposing the liver and gallbladder. A five-centimeter linear, longitudinal incision was made in the anterior face, between the first and second portions of the duodenum, with a scalpel blade no. 15. The gallbladder was then isolated from the liver

Table 1: Surgical techniques of duodenal injury repair.

| |
|---|
| Duodenal repair |
| Duodenal repair with external drainage |
| Duodenal repair with duodenostomy tube |
| Primary repair (through the duodenum) |
| Antegrade (through the pylorus) |
| Retrograde (through the jejunum) |
| Triple stoma technique (gastrostomy and jejunostomy, antegrade and retrograde) |
| Serosal jejunal patch |
| Mucosal jejunal patch |
| Vascular pedicles |
| Ileum |
| Jejunum |
| Stomach (gastric islet) |
| Duodenal resection |
| Duodeno-duodenostomy |
| Duodeno-jejunostomy |
| Duodenal diverticulization (vagotomy + antrectomy, gastro-jejunostomy, duodenal repair, biliary drainage T tube + external drainages) |
| Pyloric exclusion |
| Sutures (absorbable and nonabsorbable) |
| Mechanical suture |
| Duodeno-pancreatectomy (Whipple) |

Table 2: Univariate analysis of clinical variables.

| Variable | Single sample statistics | | | | | T-test of a sample | | | | | |
|--------------------------------------|--------------------------|------|--------|------|-------|--------------------|-----|-------|------|-----------------|-----------------|
| | n | Mean | SD | Min | Max | t | DF | p | DM | CI 95% inferior | CI 95% superior |
| Surgical time in minutes | 6 | 85.0 | 43.100 | 45.0 | 150.0 | 4.8 | 5.0 | 0.005 | 85.0 | 39.7 | 130.3 |
| Presence of bowel movements in hours | 6 | 28.0 | 9.800 | 24.0 | 48.0 | 7.0 | 5.0 | 0.001 | 28.0 | 17.7 | 38.3 |
| Start of diet in hours | 6 | 28.0 | 9.800 | 24.0 | 48.0 | 7.0 | 5.0 | 0.001 | 28.0 | 17.7 | 38.3 |
| Duodenal lesion size in centimeters | 6 | 5.0 | 0.000* | 5.0 | 5.0 | NA | NA | NA | NA | NA | NA |
| Life time in days | 6 | 28.8 | 17.800 | 9.0 | 60.0 | 4.0 | 5.0 | 0.011 | 28.8 | 10.1 | 47.5 |

* t cannot be calculated because the standard deviation is 0.

Student's t for a sample.

Min = minimum, Max = maximum, DF = degrees of freedom, p = statistical significance, DM = difference of the mean, CI 95% confidence interval, difference of the mean.

bed with blunt retrograde dissection until it was completely separated, preserving the biliary duct and the cystic artery. When dissecting and cutting the gallbladder wall, active bleeding was observed at its edges and the terminal branch of the intact cystic artery was located, both indicators of absence of vascular damage during dissection and ligation of the cystic duct. The gallbladder flap with its artery was mobilized to the site of injury in the duodenum, leaving a flap with an area one centimeter in diameter greater than the size of the lesion. It was sutured in two planes with 5-0 polypropylene (Prolene®) with an atraumatic needle, first a mucosal-mucosal layer, and later a serous-serous layer, with simple stitches. The peritoneal cavity was closed by planes; aponeurosis with Vicryl® (polyglactin 910) number 1 and skin with continuous stitches, using 2-0 Prolene®. Drainages were not used.

Animals fasted for 24 hours, they were administered antibiotic therapy (cephalotin 1 g daily for 10 days) and the feeding with sorghum and wheat was started at 24 hours.

Analysis of data

Descriptive statistics; the variables were analyzed through measurements of central tendency and dispersion, with 95% confidence intervals.

Survival analysis was carried out through Kaplan-Meier (Tables 2 and 3), estimating the average life time, as well as the value of p, where less than 0.05 were considered significant.

RESULTS

The gallbladder pedicle flap was successfully performed in six pigs; five of them tolerated initial postoperative diet at 24 hours, one until 48 hours. All presented bowel movements before 48 hours. No data were found for surgical wound infection, nor were data suggestive of intestinal leak, acute abdomen or systemic inflammatory response present. One of the pigs was reoperated nine days later, another after 14 days, three at four weeks and the last one at 60 days. A favorable clinical evolution was found in all pigs (Table 4). Photographic evidence and samples for histopathology were taken (Figures 1 and 2), which revealed fully integrated tissues in the area of the patch between the gallbladder and the duodenum. Signs of necrosis data were not observed in any sample. In the biopsy of the sacrificed case at 14 days, there were signs of inflammation and acute congestion of the biliary portion of the patch. In all the biopsies, granulomatous reaction in the zones of the suture material were found.

DISCUSSION

The presence of crepitus, bile stains in the paraduodenal tissues, biliary fistula, hematoma in the right retroperitoneal region or perirenal

hematoma should lead to suspicion of duodenal injury.¹⁶⁻¹⁸

Of all duodenal injuries, 75-85% can be primarily repaired using simple surgical techniques after careful debridement of

Table 3: Kaplan-Meier survival analysis.

| Survival table | | | | | | | |
|----------------|-------|--------|---|-------|-----------------------|----------------------|--|
| Pig | Hours | Status | Cumulative proportion of survival over time | | n of cumulated events | n of remaining cases | |
| | | | Estimate | SE | | | |
| 1 | 9.0 | Alive | 0.833 | 0.152 | 1 | 5 | |
| 2 | 14.0 | Alive | 0.667 | 0.192 | 2 | 4 | |
| 3 | 30.0 | Alive | | | 3 | 3 | |
| 4 | 30.0 | Alive | | | 4 | 2 | |
| 5 | 30.0 | Alive | 0.167 | 0.152 | 5 | 1 | |
| 6 | 60.0 | Alive | 0.000 | 0.000 | 6 | 0 | |

| Medians and medians for survival time | | | | | | | |
|---------------------------------------|-----|----------------|----------------|----------|-----|----------------|----------------|
| Mean ^a | | | | Median | | | |
| Estimate | SE | CI 95% | | Estimate | SE | CI 95% | |
| | | Inferior limit | Superior limit | | | Inferior limit | Superior limit |
| 28.8 | 7.3 | 14.6 | 43.1 | 30.0 | 4.9 | 20.5 | 39.5 |

^a Estimate is limited to the longest survival time.

Table 4: Characteristics of pigs with duodenal injury repaired using a pedicle flap of the gallbladder.

| Pig | Surgical time (min) | Bowel movements (hours) | Start of diet (hours) | Size of duodenal lesion (cm) | Time of life (days) |
|-----|---------------------|-------------------------|-----------------------|------------------------------|---------------------|
| 1 | 150 | 48 | 48 | 5 | 9 |
| 2 | 120 | 24 | 24 | 5 | 14 |
| 3 | 90 | 24 | 24 | 5 | 30 |
| 4 | 60 | 24 | 24 | 5 | 30 |
| 5 | 45 | 24 | 24 | 5 | 30 |
| 6 | 45 | 24 | 24 | 5 | 60 |

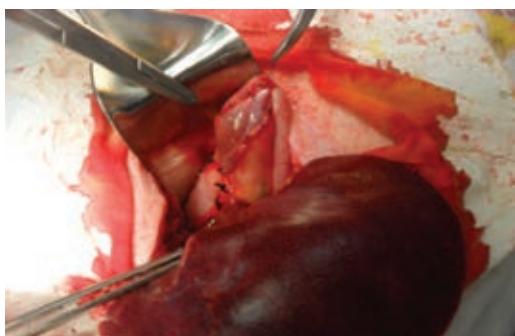


Figure 1: *Pig 1. Tissue of the gallbladder firmly attached to the duodenum, with well-faced edges, no signs of dehiscence, free liquid or bile leak.*

the borders of damaged tissue.^{19,20} *Table 1* describes different surgical techniques for duodenal injury repair.

Lesions which encompass 50% of the circumference of the duodenum, without other associated pancreatic or biliary lesions, recognized early, can be safely treated by debridement of the edges of the perforation and primary repair.^{8,21} Duodenal defects greater than 50% to 75% of the circumference, can be repaired by means of a Roux-en-Y duodeno-jejunostomy, with an end-to-end suture between one end of the jejunum and the duodenal perforation,⁶ in cases when a primary repair or anastomosis could compromise the intestinal lumen. Exclusion techniques are reserved for patients with delayed diagnosis or those with major duodenal wall defects, crush injuries, or combined pancreaticoduodenal injuries with a high probability of suture dehiscence. The complete lack of adhesion of the duodenal closure may be due to the “abstruse” anatomy of this portion of the digestive tube, its high intraluminal pressure, the tendency of the mucosa to extrude, the shared blood supply with the pancreas and self-digestion due to the effect of bile and pancreatic enzymes.²² These duodenal fistulas have been treated by apposition of a greater omentum flap, the falciform ligament, or a jejunal serous patch, as well as a Roux-en-Y duodeno-jejunostomy and exclusion or diverticulization of the duodenum.²³⁻²⁵

Duodenal injuries are routinely treated with an epiploic patch or variants of it.^{1,26} In

most cases, no loss occurs, but when repair fails, a high-output fistula ensues, leading to a significant imbalance in the internal milieu, especially in elderly patients with shock or comorbidities.²²

It is well known that healthy vascularized tissue must be used for repair of friable tissue loss. The use of a vascularized flap increases blood supply to the diseased area, accelerates healing and controls infection. Sero-muscular pedicle grafts and flaps of digestive tube have been used, demonstrating satisfactory results to salvage large duodenal defects.²⁷⁻²⁹

Agarwal and Sharma²² used “internalized” flaps of the rectus abdominis muscle to close duodenal fistulas in six patients, for cases of wide, friable-edged fistulas, when omentum was not available, or other conventional repair methods were not practicable; their success obtained in five of the six patients is to be highlighted. Ziaian and Nikravesh³⁰ designed an experimental animal study, where a repair of the duodenal defect was done by means of a jejunal pedicle flap; there were no complications and all continued with a favorable clinical course. Likewise, Katsikogiannis³¹ et al. used a pedicled gallbladder graft to cover defects of the duodenal wall in 36 dogs, with promising results: all the dogs survived and had an uncomplicated postoperative course. The repair of the defect was satisfactory, the structure and thickness of the graft remained unchanged. Like in our study, it was proved that maintaining the vascularization of a flap has promising results in terms of adhesion and epithelialization, without anastomotic

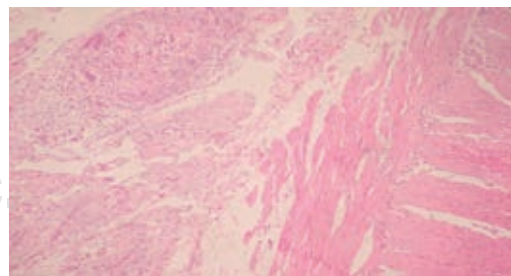


Figure 2: *40x, Pig 1. Connective tissue of the gallbladder and its union with intestinal tissue; on the far right intestinal muscle fibers and the presence of a foreign body type granuloma (suture) are found.*

leaks, intra-abdominal abscesses or intestinal obstructions.

Success in managing duodenal trauma depends on early diagnosis, volume restoration, and proper selection and practice of the repair technique,³² in addition to maintaining sufficient vascularity, both of arterial flow and venous drainage, so that it can resist the digestive properties of the duodenal content for a period sufficient to allow healing. A surgeon must be familiar with a variety of methods for managing duodenal injuries. Good surgical judgment is necessary to practice a surgical intervention proportional to the severity of the injury.

This study showed that the gallbladder pedicled flap technique is an excellent option for the repair of duodenal injuries, regardless of the mechanism of injury, as long as the circulation of the gallbladder patch is preserved; hence, it should be done with a minimum manipulation of the arterial branch. A new option is proposed, which can be put into practice in humans with duodenal injuries, and, given the viability of the flap, it could be used in the future in other procedures, such as the repair of a bile duct stenosis.

CONCLUSION

Duodenal defect repair can be accomplished by using a gallbladder flap along with its pedicle sutured to the edges of the defect, with favorable results, rather than long and complex operations.

*“Cut well, suture well
and everything will go well.”*

Anonimous

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