Review article

Duodenal Injuries Due to Trauma: Review of the Literature

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ABSTRACT

Duodenal injuries constitute a challenge to the trauma surgeon, mainly due to their retroperitoneal location. When identified, they present associated with other abdominal injuries. Consequently, they have an increased morbidity and mortality. At best estimates, duodenal lesions occur in 4.3% of all patients with abdominal injuries, ranging from 3.7% to 5%, and because of their anatomical proximity to other organs, they are rarely an isolated injury. The aim of this paper is to present a concise description of the anatomy, diagnosis, surgical management and treatment of complications of duodenal trauma, and an analysis of complications and mortality rates of duodenal injuries based on a 46-year review of the literature.

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Lesiones duodenales secundarias a traumatismo: revisión de la literatura

R E S U M E N

Las lesiones duodenales, debido a su localización retroperitoneal, constituyen un reto diagnóstico para el cirujano, de forma que son identificadas tardíamente y en consecuencia, se asocian a un aumento de la morbimortalidad. En las mejores estimaciones, las lesiones duodenales ocurren en un 4.3% de todos los pacientes con lesiones abdominales, en un rango de 3.7% a 5%, y además, debido a su proximidad anatómica con otros órganos, sus lesiones raramente se presentan en forma aislada. El objetivo de este trabajo es presentar una descripción concisa de la anatomía, diagnóstico, manejo quirúrgico y tratamiento de las complicaciones del trauma duodenal, y realizar un análisis de las complicaciones y de la mortalidad de las lesiones del duodeno en base a una revisión de la literatura de los últimos 46 años.

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Introduction

Duodenal injuries, due to their retroperitoneal location, are a diagnostic challenge to the surgeon; for this reason, they are identified in a late stage, and thus associated with increased morbidity and mortality.

The purpose of this paper is to present a brief description of the anatomy, diagnosis, surgical management and treatment of duodenal trauma complications, and to perform an analysis of the range of duodenal injury morbidity and mortality, based on an extensive review of the current literature.

Materials and Methods

A search was conducted in PubMed to find articles published in English in the last 46 years, from February 1968 to March 2014. Twenty-three case series on duodenal injuries were found. The English key words duodenal injury, duodenal injuries and duodenal trauma were used for the search.

Incidence of Duodenal Injuries

According to the best estimates, duodenal injuries occur in 4.3% of all patients with abdominal injuries, ranging from 3.7% to 5%. The proportion of duodenal injuries between male and female patients is 5–1, and the most affected age range is between 16 and 30 years (70%). In addition, the increase in the number of traffic accidents, as well as violence (knives and firearms) has led to a higher incidence in recent decades.

Mechanism of Injury

The mechanisms of the injuries caused by penetrating trauma occur by a simple lesion in the duodenal wall when it is caused by a knife, and by the penetration and dissipation of kinetic energy from the projectile in the case of gunshot injuries.

The mechanism is more complex in the case of blunt injuries, when both ends may be blunt, and duodenal injuries are a consequence of crushing or compression. Crush injuries usually occur when a direct force is applied against the abdominal wall and transmitted to the duodenum, which is then projected against the spinal column, on which it lies, for example, when the steering wheel impacts the epigastrium. They also occur when acceleration and deceleration forces act on the mobile and non-mobile portions of the duodenum, such as during a fall from a great height.

The mechanism of penetrating injury is the most common cause of duodenal trauma. In a review of the literature encompassing 24 series published during the last 46 years (1968–2014), 1760 cases of duodenal injury were identified. Out of these, 1400 (80%) occurred as a result of penetrating trauma, while 360 (20%) occurred as a consequence of blunt trauma. The range of penetrating abdominal injuries was 3.9:1 (Table 1). Among the 1400 penetrating injuries, 1135 (81%) were caused by gunshot and 257 (19%) by stabbings. Among blunt trauma, the most frequent mechanism was car crash, with a total of 306 patients (85%).

<table>
<thead>
<tr>
<th>Author and year</th>
<th>Mechanism of injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>(total no. of patients)</td>
<td>Penetrating: n (%)</td>
</tr>
<tr>
<td>Morton and Jordan,4 1968 (131)</td>
<td>117 (6.6%)</td>
</tr>
<tr>
<td>Smith, et al.,3 1971 (53)</td>
<td>46 (2.6%)</td>
</tr>
<tr>
<td>McHlnis, et al.,2 1975 (22)</td>
<td>17 (1%)</td>
</tr>
<tr>
<td>Lucas and Ledgerwood,2 1975 (36)</td>
<td>0</td>
</tr>
<tr>
<td>Mattole et al.,2 1975 (32)</td>
<td>19 (1.1%)</td>
</tr>
<tr>
<td>Kelly et al.,4 1978 (34)</td>
<td>28 (1.6%)</td>
</tr>
<tr>
<td>Stone and Fabian,3 1979 (321)</td>
<td>294 (16.7%)</td>
</tr>
<tr>
<td>Flint et al.,16 1979 (75)</td>
<td>56 (3.2%)</td>
</tr>
<tr>
<td>Snyder et al.,15 1980 (228)</td>
<td>180 (10.2%)</td>
</tr>
<tr>
<td>Levinson et al.,19 1982 (93)</td>
<td>74 (4.2%)</td>
</tr>
<tr>
<td>Adkins and Keyser,22 1984 (56)</td>
<td>39 (2.2%)</td>
</tr>
<tr>
<td>Fabian et al.,14 1984 (10)</td>
<td>0</td>
</tr>
<tr>
<td>Ivatury et al.,25 1985 (100)</td>
<td>100 (5.7%)</td>
</tr>
<tr>
<td>Bostman et al.,16 1989 (22)</td>
<td>16 (1%)</td>
</tr>
<tr>
<td>Coghill et al.,17 1990 (164)</td>
<td>102 (5.8%)</td>
</tr>
<tr>
<td>Cuddington et al.,18 1990 (42)</td>
<td>16 (1%)</td>
</tr>
<tr>
<td>Timaran et al.,19 1999 (152)</td>
<td>152 (8.6%)</td>
</tr>
<tr>
<td>Jen-Feng Fang et al.,20 1999 (18)</td>
<td>0</td>
</tr>
<tr>
<td>Jansen et al.,21 2002 (30)</td>
<td>27 (1.5%)</td>
</tr>
<tr>
<td>Seamon et al.,22 2007 (29)</td>
<td>29 (1.6%)</td>
</tr>
<tr>
<td>Rathore et al.,23 2007 (23)</td>
<td>16 (1%)</td>
</tr>
<tr>
<td>Pereira et al.,24 2008 (8)</td>
<td>5 (0.3%)</td>
</tr>
<tr>
<td>Girgin et al.,25 2009 (67)</td>
<td>59 (3.4%)</td>
</tr>
<tr>
<td>Sanjay et al.,26 2011 (14)</td>
<td>8 (0.5%)</td>
</tr>
</tbody>
</table>

Total (1760) 1400 (80%) 360 (20%)

Associated Injuries

The duodenum, by virtue of its anatomic proximity to other important organs, is rarely injured alone. The occurrence of multiple associated injuries is the rule, not the exception. Isolated duodenal injuries are usually seen in the form of duodenal haematoma.

Among the 1760 patients with duodenal trauma, a total of 3540 associated injuries were identified (Table 2). The liver was the most commonly injured organ, with a total of 600 injuries occurring with a frequency of 17%. Other organs included the colon, with 462 (13%); the pancreas, with 408 (12%); the small intestine, with 395 (11%); the stomach, with 323 (9%) and vascular injuries (arterial and venous), with 536 (15%).

Anatomic Location of Injury

To identify the most common anatomic location, 15 published series were reviewed. A total of 1042 patients were analysed. The most common duodenal injury sites were the second portion (36%), the third portion (18%) and the fourth portion (15%). The least common duodenal injury site was the first portion (13%), and injuries in multiple portions were found in 18%.
Diagnosis

The diagnosis of duodenal injury requires a high level of suspicion. Delayed diagnosis and management of these injuries results in increased morbidity and mortality rates. The diagnosis of duodenal injury is a great challenge after a blunt trauma. Information should include the haemodynamic condition of the patient, the condition in which the vehicle was found, the condition of the steering wheel, the direction of the force of the impact and the extrication path used to remove the victim from the vehicle, as well as in falls from a great height.27

When a patient undergoes secondary examination, it must be remembered that the retroperitoneal location of the duodenum usually precludes early detection of injury by physical examination, which is characterised by minimal findings. Signs of defence, abdominal rigidity and absence of bowel sounds indicate intra-abdominal injury and lead to a surgical procedure. Severe testicular pain and priapism have also been reported in association with duodenal injury, due to pain transmission through the sympathetic fibres running along the gonadal vessels.28

Laboratory tests provide little help in the early diagnosis of duodenal injuries. The serum amylase level is usually considered a possible indicator of duodenal injury; however, due to its low sensitivity and specificity, it must not be used as an indicator of exploratory laparotomy.29 On the other hand, the serum amylase level has a predictive value in the case of patients admitted for observation. Lucas and Ledgerwood3 suggested that the serum amylase level should be determined at 6-h intervals. A persistently elevated amylase level may be of prognostic significance in detecting duodenal injury.

Abdominal X-ray is useful only if it is positive, the presence of gas surrounding the right kidney being one of its characteristic signs. With wide experience in the use of serial gastrointestinal X-ray examination, Felson and Levin30 described the “coil spring sign”, found in the gastrointestinal barium X-ray, which could be diagnostic of intramural duodenal haematoma.

In 1974, Corley et al.,7 published a series of 17 patients with duodenal rupture in blunt trauma, and evaluated the radiographic findings as to the presence of intraperitoneal free air. These researchers suggested that positive radiographic findings in abdominal plates appeared more commonly in patients with penetrating trauma than in those who suffered blunt trauma. These radiographic findings have also been documented by Stone and Fabian.10

The best method to visualise retroperitoneal organs without an operation is a computed tomography (CT) scan with oral and intravenous contrast. Despite the fact that the use of CT scanning is limited to stable patients, it has proved capable of showing retroperitoneal ruptures of the duodenum, apart from visualising retroperitoneal organs, detecting injuries of the hollow viscera and quantifying intraperitoneal free blood.

Retroperitoneal perforation of the duodenum can be visualised in the CT scan as the leakage of intestinal contents into the lesser sac. These perforations are typically contained and located in this cavity, but occasionally may be in communication with the peritoneal cavity through the foramen of Winslow and produce pneumoperitoneum. In these cases, an examination with Gastrografin26 (Bristol-Myers Squibb, Evansville, IN) could reveal the perforation site. In most patients, the contrast medium should be administered slowly through a nasogastric tube so that the duodenal bulb is filled properly, and its distal end should preferably be in the gastric fundus.

The ideal patient position is the right lateral decubitus position. If no leakage is observed, the patient should be placed in the supine position and X-rays repeated, including stomach and duodenum. The test is completed by placing the

<table>
<thead>
<tr>
<th>Table 2 – Associated Injuries by Organs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author and year</td>
</tr>
<tr>
<td>Corley et al. (1974)</td>
</tr>
<tr>
<td>McInnis et al. (1975)</td>
</tr>
<tr>
<td>Lucas and Ledgerwood (1975)</td>
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<tr>
<td>Matolo et al. (1975)</td>
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<td>Kelly et al. (1978)</td>
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<tr>
<td>Stone and Fabian (1979)</td>
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<tr>
<td>Flint et al. (1979)</td>
</tr>
<tr>
<td>Snyder et al. (1980)</td>
</tr>
<tr>
<td>Levinson et al. (1982)</td>
</tr>
<tr>
<td>Adkins and Keyser (1984)</td>
</tr>
<tr>
<td>Cogbill et al. (1990)</td>
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<tr>
<td>Timaran et al. (1999)</td>
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<tr>
<td>Jen-Feng Fang et al. (1999)</td>
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<tr>
<td>Jansen et al. (2002)</td>
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<tr>
<td>Seamon et al. (2007)</td>
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<tr>
<td>Pereira et al. (2008)</td>
</tr>
<tr>
<td>Girgin et al. (2009)</td>
</tr>
<tr>
<td>Sanjai et al. (2011)</td>
</tr>
<tr>
<td>600</td>
</tr>
</tbody>
</table>

BT: biliary tree; MA: major arteries; GU: genitourinary; SI: small intestine; MV: major veins.
patient in the left lateral position, which allows better visualisation of the antrum and duodenum. The best method to visualise the retroperitoneal organs is CT scanning with intravenous and intraluminal contrast.\textsuperscript{31}

In a review conducted by Ballard et al.,\textsuperscript{32} which included 30 patients with duodenal blunt trauma, 18 underwent CT scanning as a method for diagnosing duodenal injury, and in most cases (15 patients), it was performed within the first 4 h after admission. The presence of intraperitoneal fluid was the most common finding, 11 cases being reported (73%), followed by the detection of duodenal haematoma in 6 (40%) and pneumoperitoneum in 5 (33%). Moreover, in four patients (27%) with complete duodenal rupture, the CT scan was interpreted as normal. These authors conclude that the “pathognomonic” findings of duodenal trauma, such as the presence of retroperitoneal air and contrast extravasation, only occur in a minority of cases.

Hofer and Cohen\textsuperscript{33} have described two patients with duodenal perforation secondary to blunt abdominal trauma. The CT scan showed thickening of the duodenal wall, interruption of the contrast medium flow and presence of extraluminal gas and fluid as consistent findings of duodenal injury. The authors conclude that administration of oral contrast maximises CT findings.

Diagnostic peritoneal lavage (DPL), although quite obsolete, can help rule out associated intra-abdominal injuries.\textsuperscript{7,9}

### Surgical Management of Duodenal Injuries

The immediate control of bleeding from vascular structures or solid organs, such as the kidney or spleen, must be the gold standard manoeuvre in abdominal trauma surgery, followed by an immediate control of gastrointestinal contamination. The next step in a trauma laparotomy must consist of a thorough examination of the abdominal cavity. The entire duodenum, including its four portions, must be carefully explored. Findings suspicious of the presence of a duodenal injury include duodenal subcutaneous emphysema, bile in the duodenal wall, free biliary fluid, the presence of retroperitoneal haematoma around the duodenum or a perirenal haematoma. The duodenum must be mobilised through a Kocher manoeuvre, a Cattell and Braasch manoeuvre, or both. These manoeuvres must enable the visualisation of all the anterior and posterior walls of the four portions of the duodenum.

The American Association for the Surgery of Trauma in agreement with the Organ Injury Scale Committee (AAST-OIS) divided injuries into grades (Table 3).\textsuperscript{34}

<table>
<thead>
<tr>
<th>Grade</th>
<th>Injury</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Haematoma</td>
<td>Involves only one duodenal portion.</td>
</tr>
<tr>
<td></td>
<td>Laceration</td>
<td>Partial laceration, without perforation.</td>
</tr>
<tr>
<td>II</td>
<td>Haematoma</td>
<td>Involves more than one portion.</td>
</tr>
<tr>
<td></td>
<td>Laceration</td>
<td>Less than 50% disruption of the circumference.</td>
</tr>
<tr>
<td>III</td>
<td>Laceration</td>
<td>50%-75% disruption of D2 circumference</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50%-100% disruption of D1, D3 and D4 circumference.</td>
</tr>
<tr>
<td>IV</td>
<td>Laceration</td>
<td>More than 75% disruption of D2 circumference</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Involves the ampulla or the distal portion of the common bile duct</td>
</tr>
<tr>
<td>V</td>
<td>Laceration</td>
<td>Massive disruption of the duodenopancreatic system</td>
</tr>
<tr>
<td></td>
<td>Vascular</td>
<td>Duodenal devascularisation</td>
</tr>
</tbody>
</table>

* Advance one grade for multiple injuries in the same organ.

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The trauma surgeon must be able to handle different surgical procedures based on injury complexity (Table 4). Controversies have been raised in relation to the use of adjacent manoeuvres to protect the duodenal closure. One of these manoeuvres is the tube duodenostomy technique, which is divided into three types: (a) primary, where the tube is inserted in an orifice different from the wound; (b) antegrade, where the duodenum is decompressed by passing a tube through the pylorus towards the duodenum and (c) retrograde, where the tube is passed through the jejunalostomy site.

In 1979 Stone and Fabian\textsuperscript{10} introduced the use of the duodenostomy tube as “triple ostomy” (gastrostomy, duodenostomy and jejunostomy). They included 237 patients and only 1 case of duodenal fistula was registered when the duodenostomy tube was used, compared to 8 patients with fistula when it was not used.

In comparison, Ivatury et al.\textsuperscript{35,36} found an increase in the occurrence of duodenal fistula and complications in those patients subject to duodenal decompression.
Snyder et al.,\textsuperscript{12} did not find significantly statistical
differences among 101 patients treated with duodenorrhaphy and
decompression (9 fistulas, 9\%) and 89 patients treated with
duodenorrhaphy alone (5 fistulas, 6\%).

Since the 1960s, the use of mucosal or serosal patches
appeared as a tool within the range of surgical options in
duodenal trauma, given that experimental models had shown
that the apposition of serous membrane of mobilised jejunal
loop to seal full-thickness, non-reconstructible duodenal
injuries induced mucous coat in six to eight weeks.\textsuperscript{37–39}
In the 1970s, advances in experimental models, which used,
on the one hand, pedunculated jejunal mucosal flaps
anastomosed to the defect with double-layer technique,\textsuperscript{39}
and on the other hand, a “pedunculated gastric island” from
the greater curvature supplied by the gastroepiploic vessels.\textsuperscript{40}
In the 1990s, the use of pedunculated flaps of the transversus
abdominis muscle, which showed good healing in the models,
was published in another experimental series.\textsuperscript{41} However, no
studies have been conducted with sound evidence justifying
its use in patients with duodenal trauma.

If the entire duodenal circumference has been devitalised,
a segmental resection and an end-to-end duodenal anastomosis
may be carried out. The resection of the first, third and
fourth portions of the duodenum is not associated with a high
risk of vascular involvement. The limiting step in the resection
of the second portion is attributed to the arterial arcade shared
with the pancreas.

Patients with severe duodenal injuries must be considered
candidates for complex duodenal repair, such as duodenal
diverticulization or pyloric exclusion. Such injuries include
those caused by blunt or penetrating trauma, involving more
than 75\% of the wall, the first and second portions of
duodenum, those associated with a delayed repair of more
than 24 h and those associated with a pancreatic injury,
common bile duct injury or both. The main purpose of these
procedures is to exclude the duodenum from the passage of
gastric contents, to allow time for duodenal repair and to
prevent suture line dehiscence. For such purpose, a temporary
pyloric closure and transit reconstruction are performed by a
gastrojejunostomy. The pyloric exclusion has the advantage of
preventing antral resection.

The original duodenal diverticulization was described by
Berne et al.\textsuperscript{42} in 1968. The procedure includes antrectomy and
gastrojejunostomy, truncolar vagotomy, wound excision and
duodenorrhaphy, duodenostomy, Kehr’s tube and feeding
jejunosomy.

Duodenopancreatectomy for complex duodenal injury was
first suggested by Thal and Wilson\textsuperscript{43} in 1964. Indications to
perform a Whipple procedure include massive, uncontrollable
bleeding of the head of pancreas or adjacent vascular
structures, or isolated or combined non-reconstructible
injuries in the duodenum, the head of pancreas and the
common bile duct.\textsuperscript{44}

In their 126-month study on duodenopancreatectomy,
Asensio and Petrone\textsuperscript{45} reported their series of 18 patients, out
of which one underwent a thoracotomy in the emergency
room and was alive upon arrival at the operating room where
she/he died. In the 17 remaining patients, a survival of 67\%
was recorded, compared to 64\%–67\% shown in literature,
considering the severity of injuries, the significant blood loss
and the large number of associated abdominal vascular
injuries.

Morbidity

Duodenal lesions are also associated with a high morbidity
rate; complications are mainly represented by fistulas
resulting from surgical repair failure due to suture line
dehiscence, and are occasionally represented by duodenal
obstruction. In a review of the latest 7 series, 19–25 with a total
of 341 patients, a morbidity rate of 22\% was observed. Fifty-
one (51) cases of intra-abdominal abscess (15\%), 21 of
duodenal fistula (6\%), 3 of duodenal obstruction (0.9\%) and
2 cases of recurrent pancreatitis (0.5\%) were reported. Fakhry
et al.,\textsuperscript{46} in a multicentre retrospective study comprising 318
patients with duodenal trauma recorded a morbidity rate of
27.1\%.

Mortality

Mortality secondary to trauma with duodenal involvement
may be divided into early and late. Early deaths are caused by
exsanguination, usually resulting from associated major
vascular injuries, while late deaths are caused by sepsis,
duodenal fistula and multiple organ failure. The overall
mortality rate reported in recent series was 5.3\%–30\%.\textsuperscript{2,3–14}

Factors known to increase the mortality rate include
associated pancreatic injury\textsuperscript{2,10} and common bile duct injury.
The most important associated factor for determining
duodenal injury mortality may be the delay in injury
recognition and repair time. Snyder et al.\textsuperscript{12} reported a
mortality of 50\% in patients who underwent delayed surgery,
with a fistula incidence of 50\%. In 1975 Lucas and Ledgerwood\textsuperscript{8}
suggested that a delay in diagnosis and treatment greater than
24 h may increase mortality from 11\% to 40\%.

In a paper on the experience in Los Angeles County and the
University of Southern California Trauma Centre, correlation
between mortality and duodenal injury grade according to the
AAST-OIS classification was the following: grade i: 1/12 (8.3\%);
grade ii: 9/48 (18.7\%); grade iii: 16/57 (27.6\%); grade iv: 4/13
(30.8\%) and grade v: 10/17 (58.8\%).\textsuperscript{46}

Special Situations

The most common cause of duodenal rupture is the epigastric
impact of the steering wheel. The best way to establish the
diagnosis is by CT with oral or intravenous contrast, or by
serial gastrointestinal X-ray examination. The consequences
of duodenal rupture are accompanied by a fistula onset rate of
up to 50\%,\textsuperscript{2,12} and mortality between 40\% and 71%.\textsuperscript{2,4,7,8,12}  

Another type of duodenal injury requiring special consi-
deration is intramural duodenal haematoma. This is usually
caused by a blunt abdominal trauma and may occur in any
part of the duodenum. Its incidence has been associated with
coagulation disorders, anticoagulant therapy and alcohol
abuse. Intramural duodenal haematomas occur as a conse-
quence of vascular rupture inside the duodenal wall. Most of
them are submucosal, but subserosal ones have also been reported in intramuscular areas. Patients with this condition initially require a nasogastric tube and parenteral nutrition. If the duodenal haematoma does not resolve within two to four weeks, surgery will be indicated. Duodenal injuries may also occur after endoscopic procedures, such as the upper gastrointestinal endoscopy and endoscopic retrograde cholangiopancreatography (ERCP). Bleeding from the ampulla of Vater after endoscopic sphincterotomy may occur and, although rarely, a surgical procedure may be required.

**Conclusion**

Once the need for a surgical procedure is established, duodenal injury extension and its relation to other structures should be carefully assessed and an adequate surgical treatment should be applied in each case, saving the more complicated techniques, such as diverticulization and pyloric exclusion, for the more complex injuries, while most injuries will only require simple techniques such as wound excision and duodenorrhaphy.

The high mortality rate related to duodenal trauma is affected mostly by the existence of associated injuries, among which penetrating injuries are the ones that involve greater intraoperative blood loss and shock.

**Conflicts of Interest**

The authors declare that they do not have any conflicts of interest.

**REFERENCES**


