ORIGINAL ARTICLE

Incidence of vascular lesions associated with disruption of the bile duct secondary to cholecystectomy

Incidencia de lesiones vasculares asociadas a disrupción de la vía biliar secundaria a colecistectomía

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Abstract

Background: *One of the most serious complications of cholecystectomy is bile duct disruption, which can be associated with concomitant vascular injury in up to 3.4%. The incidence, demographic characteristics and treatment are underreported worldwide.* **Objective:** *To determine the incidence of vascular lesions in patients with a diagnosis of bile duct disruption secondary to cholecystectomy from January 1, 2015 to December 31, 2019, confirmed by preoperative CT angiography or intraoperative findings.* **Method:** *Retrospective, observational and analytical study of a series of cases between 2015 and 2019. Where a total of 144 cases of bile duct disruption were found, 15 cases (10%) with concomitant vascular injury.* **Results:** *The most frequent vascular injury was of the right hepatic artery in 13 patients (87%). The level of biliary disruption most frequently associated was Strasberg E3 and E4 in 5 patients (36%), respectively. The treatment of vascular injury was ligation of the injured vessel in 11 patients (73%). The treatment established for the repair of biliary disruption was the hepatic jejunum anastomosis in 14 patients (93%).* **Conclusions:** *The presence of injury at the level of the right hepatic artery is the most frequent and its ligation did not show a significant impact on biliodigestive reconstruction, as long as an adequate technique is performed (Hepp-Couinaud).*

Keywords: *Bile duct disease. Vascular injury. Cholecystectomy.*

Resumen

Antecedentes: *Una de las complicaciones más serias de la colecistectomía es la disrupción de la vía biliar, la cual puede estar asociada con lesión vascular concomitante hasta en un 3.4%. Su incidencia, características demográficas y tratamiento son infrarreportados en todo el mundo.* **Objetivo:** *Conocer la incidencia de las lesiones vasculares en pacientes con diagnóstico de disrupción de la vía biliar secundaria a colecistectomía, del 1 de enero de 2015 al 31 de diciembre de 2019, confirmado por angiotomografía preoperatoria o por hallazgos transoperatorios.* **Método:** *Estudio retrospectivo, observacional y analítico de una serie de casos del 2015 al 2019. Encontrando 144 casos de disrupción de la vía biliar, 15 (10%) con lesión vascular concomitante.* **Resultados:** *La lesión vascular más frecuente fue la de arteria hepática derecha, en 13 pacientes (87%). El nivel de disrupción biliar más habitualmente asociado fue Strasberg E3 y E4, en 5 pacientes (36%) cada uno. El tratamiento de la lesión vascular fue ligadura del vaso en 11 pacientes (73%). El tratamiento de la disrupción de vía biliar fue anastomosis hepático-yeyunal en 14 pacientes (93%).* **Conclusiones:** *La presencia de lesión de la arteria hepática derecha*

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es la más frecuente y su ligadura no tiene una repercusión significativa en la reconstrucción biliodigestiva, siempre y cuando se realice una técnica adecuada (Hepp-Couinaud).

Palabras clave: *Enfermedad de la vía biliar. Lesión vascular. Colecistectomía.*

Introduction

Gallbladder surgery is one of the most frequently performed surgical procedures in our population. One of the most serious complications is biliary tract disruption, which occurs in 0.2% to 0.3% of all cases of open cholecystectomy and in 0.5% to 0.8% of all cases of laparoscopic cholecystectomy; in 3.4% of the cases, it is accompanied by concomitant vascular injury[1,2].

Predisposing factors for biliary vascular injury include anatomical variations (which hinder the identification of structures), cholecystectomy performed during the acute phase of inflammation, antegrade dissection of the gallbladder, and lack of surgical experience[3].

In patients with biliary vascular injury, the structures are often located underneath and behind the gallbladder due to inflammatory contraction. In these circumstances, the cystic plate may become short and thick, significantly reducing from 3 cm down to 4 cm. If the dissection plane of cholecystectomy is behind and continues downward from the plate, a fibrous sheath around the right portal pedicle may eventually be found. If this structure is cut, the bile duct and blood vessels inside the sheath may be injured[3,4].

As a safety measure during cholecystectomy, the development of critical safety vision is vital to minimize the risk of biliary tract disruption. Gallbladder or liver retraction, pericholecystic adhesions, and difficulties locating the gallbladder are signs to avoid performing antegrade gallbladder dissection, aiming at a safer and more limited procedure such as cholecystostomy or subtotal cholecystectomy[4,5].

The right hepatic artery is the most frequently injured one, with an incidence rate of 7% (in patients undergoing autopsies after cholecystectomy), while in patients with biliary tract disruption, it goes up from 11% to 47% (in patients studied by angiography). Because it is located right behind the common hepatic duct, it is the most affected structure in a high disruption.

It often goes unnoticed or unidentified until imaging studies or autopsies are performed[6].

The incidence rate of portal vein injury is 4%, ranking second in vascular injuries related to biliary tract disruption, often along with common hepatic artery injury, and also associated with increased morbidity, complex management, and a high mortality rate[7,8].

The objective of this study was to understand the demographic and epidemiological characteristics of patients with vascular injuries and a diagnosis of biliary tract disruption, as well as their treatment, at a tertiary reference hospital in Mexico City.

Method

This was a case series of patients treated at a tertiary referral center from Mexico City from January 1, 2015 through December 31, 2019, with a diagnosis of vascular injury associated with biliary tract disruption due to cholecystectomy confirmed by preoperative coronary computed tomography angiography or intraoperative findings.

Inclusion criteria were being older than 18 years, having a diagnosis of biliary tract disruption and concomitant vascular injury, and having undergone surgical management.

All patients with incomplete biliary injuries (Strasberg A, B, C, and D) were excluded. Patients whose health records had been lost, or with missing data were excluded as well.

Descriptive statistics were expressed as means (± standard deviation) for quantitative variables, and frequencies and percentages for qualitative ones. Management, the surgery performed, and the postoperative progression of both the reconstruction and the liver were documented. All analyses were performed using SPSS 25 for Mac (Chicago, IL, United States).

Results

A total of 144 patients with biliary tract disruption were surgically treated from January 1, 2015 through December 31, 2019, 15 of whom (10%) had associated vascular injury following cholecystectomy. Five patients (33%) were men, and 10 (67%), women. Their mean age was 44.53 (± 18) years.

The most common initial surgical approach in cholecystectomy was laparoscopic in 14 (93%) patients, 7 (47%) started with laparoscopy and crossed over to open surgery, and 1 (7%) patient was treated with open surgery from the beginning. Intraoperative findings reported the presence of scleroatrophic gallbladder in 3 (21%) patients, Calot's triangle fibrosis in 2 (13%), gallbladder adhesions to the biliary tract in 2 (13%), and anatomical anomalies, pyocholecyst, and hydrocholecyst in 1 (7%) patient. Biliary tract disruption was identified intraoperatively in 8 (53%) patients and postoperatively in 7 (47%) (Table 1). A total of 14 patients (93%) were referred from other units. The mean time elapsed between cholecystectomy and referral to a tertiary center was 9.4 (± 8.56) days.

As part of the study upon admission to our unit, a coronary computed tomography angiography was performed in 8 (53%) patients, which revealed the presence of vascular injury (Fig. 1); other preoperative imaging modalities included endoscopic retrograde cholangiopancreatography in 2 (13%) patients and tube cholangiography in 1 (7%). No studies were performed in 4 patients (27%) at admission due to hemodynamic instability. Also, vascular injury was documented intraoperatively.

According to the Strasberg classification, the most common disruptions were type E3 and E4 in 5 (36%) patients each, followed by type E2 in 3 (21%) patients, and type E5 in 1 (7%).

The most common vascular injury was found in the right hepatic artery in 12 patients (80%), followed by main portal vein injury and concomitant right hepatic artery injury in 1 (7%), left hepatic artery injury and main portal vein injury in 1 (7%), and right hepatic artery aneurysm in 1 (7%) patient.

As part of the surgical treatment of biliary tract disruption, an open hepaticojejunostomy procedure was performed using the Hepp-Couinaud technique in 14 patients (93%), while 1 (7%) patient underwent stenting over the biliary tract disruption site and drainage due to hemodynamic instability at admission. To treat vascular injury, ligation was performed in 11 (73%) patients, primary closure in 3 (21%), and aneurysmectomy in 1 (7%) patient. The median time elapsed between admission and the definitive surgical treatment was 4 days (range, 0-30), the mean intraoperative time was 231.67 min (± 67.180), the mean intraoperative bleeding volume was 833.33 mL (± 840.42), and the median postoperative length of stay, 15 days (range, 1-156).

Table 1. Characteristics of the patients included in the study (n = 15)

Age, years	44.53 (± 18)
Gender, M/W	5/10 (33/67%)
Initial approach of cholecystectomy (laparoscopic/Open)	14/1 (93/7%)
Initial surgical findings of cholecystectomy	
Scleroatrophic gallbladder	3 (21%)
Calot's triangle fibrosis	2 (13%)
Gallbladder adherences to bile duct	2 (13%)
Anatomical abnormalities	1 (7%)
Pyocele	1 (7%)
Hydrops	1 (7%)
None	5 (33%)
Identification moment of bile duct disruption	
Intraoperative	8 (53%)
Postoperative	7 (47%)

The presence of biliary vascular injury and the development of postoperative medical and surgical complications are associated with higher morbidity and mortality rates. In our study, the morbidity rate stood at 67% (Table 2).

In the postoperative period, the most common medical complications were pneumonia in 4 (27%) patients, septic shock due to cholangitis in 3 (21%), hypovolemic shock in 3 (21%), acute kidney injury in 2 (13%), and multiple organ failure in 1 (7%) patient.

Among the surgical complications following the surgical procedure, the most common immediate postoperative complications reported within the first 24 hours were transient hepatic ischemia in 2 (13%) patients and acute liver failure in 1 (7%). In the immediate postoperative (24 hours to 7 days) the following complications were reported: right hepatic abscesses in 2 (13%) patients, residual abscesses in 2 (13%), surgical site infection in 1 (7%), biloma in 1 (7%), and seroma in 1 (7%) patient. Late complications (> 7 days after surgery) included incisional hernia in 2 (13%) patients, hepatic atrophy in 1 (7%), biliary fistula in 2 (13%), bilioenteric stenosis in 1 (7%), and granuloma in 1 (7%) patient. A total of 6 patients (40%) did not experience any surgical complications.

One patient (7%) with left hepatic artery and main portal vein injury who underwent ligation resulted in death (Fig. 2). It was impossible to perform biliodigestive diversion due to hemodynamic instability. Eventually, the patient died 12 hours after surgery from acute liver failure and multiple organ failure.

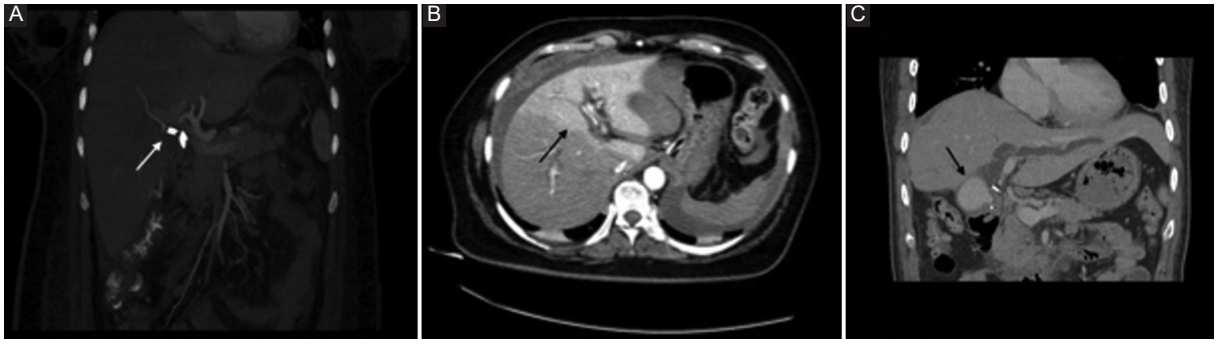

Figure 1. A: *coronary computed tomography angiography showing a right hepatic artery injury due to clip placement following laparoscopic cholecystectomy.* **B:** *coronary computed tomography angiography showing a significant perfusion abnormality in the right hepatic lobe following a right hepatic artery injury.* **C:** *coronary computed tomography angiography showing a right hepatic artery pseudoaneurysm following this injury.*

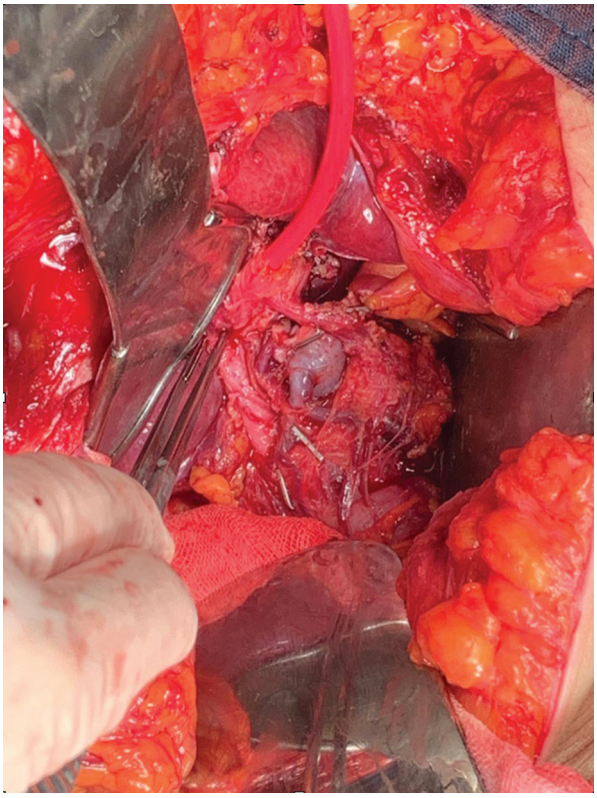

Figure 2. *Left hepatic artery injury, and injury to the main portal vein with presence of laparoscopic clips.*

Discussion

Cholecystectomy is indicated in cases of symptomatic gallstone disease and is one of the most common procedures in digestive surgery. It is primarily performed using laparoscopy by dissecting Calot's triangle and achieving the critical view of safety as described by Strasberg. Anatomical variations and inflammation of the gallbladder and the hepatocystic triangle can complicate this surgical procedure and increase the risk of biliary vascular injuries, which surgeons should always try to avoid. In perioperative difficult cases, the surgeon should not hesitate to seek assistance, cross over to open surgery, or perform a partial or subtotal cholecystectomy in the presence of significant inflammation[9].

Biliary disruption can have both short- and long-term complications, leading to long admissions, additional interventions, and diminishing these patients' quality of life. Undoubtedly, these patients are a surgical challenge, and their management requires the skills of hepatobiliary surgeons in specialized centers[9].

Biliodigestive reconstructions have successful results in 75% to 98% of the cases in landmark referral hospitals. Various factors can affect the results and complications of such procedures, including the timing of reconstruction, associated sepsis, vascular injury, and the use of transanastomotic biliary stents. Results and complications can also be impacted if patients were referred after prior reconstruction outside a tertiary referral center, or based on the timing and circumstances surrounding such referral[10].

The right hepatic artery is, by far, the vessel most commonly damaged in biliary vascular injuries (> 90%), either in isolation or associated with bile duct injuries. Studies suggest that the incidence of right hepatic artery injury in patients with main biliary tract disruption associated with laparoscopic cholecystectomy could be around 25%, although centers that systematically use coronary computed tomography angiography in patients with biliary tract disruption have reported rates as high as 41% to 61% due to its proximity to the common hepatic duct[10].

Table 2. Characteristics, type of vascular and biliary injury, management of vascular injury, and outcomes in 15 patients diagnosed with biliary vascular injury

Patient	Age	Sex	Preoperative status	Type of vascular injury	Type of biliary Injury (Strasberg)	Management of vascular injury	Postoperative complications (Surgical)	Postoperative complications (Medical)	Final patient outcomes/ Hepatic evolution
1	52	Woman	Stable	RHA	E2	Ligature	IC: none ICM: none LC: none	IC: none ICM: none LC: none	Good / Good
2	26	Woman	Unstable cholangitis	RHA	E2	Ligature	IC: none ICM: residual abscess LC: none	IC: AKI, septic shock ICM: none LC: pneumonia	Good / Good
3	40	Woman	Stable	RHA	E4	Ligature	IC: none ICM: none LC: none	IC: none ICM: none LC: none	Good / Good
4	63	Man	Stable	RHA	E3	Repair	IC: none ICM: right hepatic abscess LC: right hepatic atrophy, bilioenteric stenosis, biliary fistula, incisional hernia	IC: none ICM: none LC: none	Poor, bilioenteric stenosis / Right hepatic atrophy
5	32	Man	Stable	RHA	E4	Aneurysmectomy	IC: none ICM: residual abscess LC: granuloma	IC: hypovolemic shock (intraoperative bleeding ICM: none LC: none	Good / Good
6	18	Woman	Unstable cholangitis	RHA and MPV	E4	Ligature	IC: none ICM: right hepatic abscess LC: none	IC: Septic shock, IMC: none LC: Pneumonia, anemia, delirium, seizure	Poor due to severe AKI / Good
7	62	Woman	Stable	RHA	E3	Ligature	IC: transient hepatic ischemia IMC: none LC: none	IC: none ICM: none LC: none	Good / Good
8	24	Woman	Stable	RHA	E4	Repair	IC: none ICM: none LC: none	IC: none ICM: none LC: none	Good / Good
9	28	Man	Stable	RHA	E3	Ligature	IC: transient hepatic ischemia IMC: surgical site infection, seroma LC: biliary fistula	IC: none ICM: none LC: none	Good / Good
10	68	Woman	Stable	RHA	E2	Ligature	IC: none ICM: none LC: Incisional hernia	IC: none ICM: none	Good / Good
11	37	Man	Stable	RHA	E3	Ligature	IC: none ICM: none LC: none	IC: AKI ICM: none LC: pneumonia	Good / Good

(*Continues*)

Table 2. Characteristics, type of vascular and biliary injury, management of vascular injury, and outcomes in 15 patients diagnosed with biliary vascular injury *(continued)*

Patient	Age	Sex	Preoperative status	Type of vascular injury	Type of biliary Injury (Strasberg)	Management of vascular injury	Postoperative complications (Surgical)	Postoperative complications (Medical)	Final patient outcomes/ Hepatic evolution
12	48	Woman	Stable	RHA	E3	Ligature	IC: none ICM: none LC: none	IC: none ICM: none LC: none	Good / Good
13	72	Woman	Unstable hypovolemic shock	LHA and MPV	E5	Ligature	IC: acute liver failure ICM: none LC: none	IC: Hypovolemic shock, pneumothorax due to CVC, multiple organ failure ICM: none LC: none	Poor, multiple organ failure and death / acute liver failure
14	33	Woman	Unstable cholangitis	RHA	E3	Ligature	IC: none ICM: biloma LC: none	IC: Septic shock, hypovolemic shock (intraoperative bleeding) IMC: none LC: none	Good / Good
15	65	Man	Stable	RHA	E4	Repair	IC: none ICM: none LC: none	IC: none ICM: none LC: none	Good / Good

AKI: acute kidney injury; CVC: central venous catheter; IC: immediate complications (< 24 h); IMC: intermediate complications (24 h to 7 days); LC: late complications (> 7 days); LHA: left hepatic artery; MPV: main portal vein; RHA: right hepatic artery.

Cases of right hepatic artery injury without bile duct involvement often present as occlusions, or pseudoaneurysms and rarely exhibit clinical symptoms or signs. Other arteries less commonly affected include the left hepatic artery, common hepatic artery, and marginal vessels.

Injuries to the portal vein associated with biliary tract injuries often occur in the context of massive bleeding requiring emergency vein ligation. This leads to acute liver failure, requiring emergency procedures like hepatectomy or liver transplant. We should mention that cases involving > 1 diseased vessels have been reported[10].

The most frequent vascular injury found in our study was the right hepatic artery injury, which is similar to what has been reported by the scientific medical literature available, with an incidence rate of 87%, which is consistent in up to 90% of the findings published. The second most common vascular injury found was the main portal vein injury, with an incidence rate of 13%, which is higher than the 4% reported by the medical literature, and in our study, was associated with right hepatic artery injury (1 case) and left hepatic artery injury (1 case)[11].

The factors most often associated with predisposition to vascular injury were the presence of sclero-atrophic gallbladder, fibrosis of Calot's triangle, and adhesions of the gallbladder to the biliary tract, which are similar findings to those reported in the medical literature currently available. These factors were also associated with portal vein injuries due to the shortening and thickening of the cystic plate, significantly reducing it from 3 cm to 4 cm and changing the anatomical structures, making vascular injury and biliary tract disruption more likely[11].

As the initial assessment of vascular injury in patients with biliary tract disruption, a coronary computed tomography angiography should be performed as a confirmatory study if the patient's conditions allow it. Therefore, when examining a patient with biliary vascular injury, it is essential to establish the status of hepatic arterial supply, especially when excising the

biliary confluence is required, particularly in patients with failed primary management of biliary tract disruption[12].

The type of biliary tract disruption most often associated with vascular injury in our study corresponds to Strasberg types E3 and E4 (36%), which is similar to what has been reported by the medical literature available (29%). This is because the right hepatic artery runs around the common hepatic duct at this level, which explains the higher association with vascular injury. Types E1 and E2 injuries tend to progress intraoperatively to E3 and E4 injuries due to biliary tract ischemia[13].

Although Strasberg et al.[3] recommend a 3-month waiting period before biliary tract repair, the established treatment in our unit regarding the repair of biliary tract disruption was open hepaticojejunostomy using the Hepp-Couinaud technique to adequately preserve anastomotic vascularity, as described by Alves et al.[2] This was performed in 93% of our patients, which explains the optimal results > 90% in our unit regarding the management of concomitant vascular injuries.

As part of the treatment of the right hepatic artery injury, some authors suggest arterial reconstruction to prevent liver necrosis, bilioenteric anastomotic leak, and late biliary stenosis. Arterial reanastomosis using a termino-terminal technique is often possible only if the injury is associated with a partial or complete transection of the vessel and performed after immediate conversion to laparotomy. Other authors recommend ligating the right hepatic artery in cases where arterial anastomosis is not feasible, as collateral circulation from the hilar plate provides enough arterial flow to the hepatic confluence and the extrahepatic portion of the left hepatic duct[13].

In 73% of the cases, the vascular injury was treated by ligating the hepatic artery. In 20% of the cases, vascular repair was performed as described in the medical literature, using 6-0 vascular Prolene sutures to preserve biliary duct vascularity and facilitate biliodigestive diversion. Regarding vascular injuries with late complications such as right hepatic artery pseudoaneurysm, aneurysmectomy and open biliodigestive diversion were performed in a single procedure to reduce the morbidity of 2 invasive interventions. However, the medical literature available recommends angioembolization as the first-line therapy[13].

In our study, the most common medical complications were pneumonia (27%), abdominal sepsis (27%), and hypovolemic shock (21%), directly associated with vascular injury, the ones that also trigger recurrent biliary stenosis. However, in our study, only 1 case (7%) was reported of a complication of the right hepatic artery injury, which explains the adequate preservation of anastomotic vascularity using the Hepp-Couinaud technique despite vascular injury with biliary tract disruption. The most common immediate postoperative complications were right hepatic abscess due to hepatic ischemia in 13% of the cases. These ischemic changes can be identified 4 days after right hepatic artery injury and have been reported in the medical literature in 11% to 67% of the patients with right hepatic artery injury and biliary tract disruption[14].

Our study found a high mortality rate in cases of portal vein injury, involving 2 patients, one of whom died due to vascular injury-related complications (hypovolemic shock and acute liver failure). This type of injury has been reported in the medical literature with mortality rates from 50% to 100%, being the primary cause exsanguinating hemorrhage, as it was the case with our patient. The survival rate with portal vein ligation is close 60% in patients with large or complex injuries when performed as a damage control measure. If the patient survives the initial laparotomy, planned recovery occurs within 24 to 48 hours to mitigate abdominal compartment syndrome and assess intestinal viability. Portal vein repair is often performed by suturing, although reconstruction can be challenging, complicated by massive hemorrhage, and rarely managed successfully. In our study, the mortality rate reported is similar to that reported by the medical literature available and involves a small percentage of all biliary vascular injuries[14].

In the current laparoscopic era, biliary vascular injuries tend to be associated with a higher incidence rate of proximal injuries compared to open surgery. These injuries have become increasingly common despite the availability of multiple safety techniques. Their frequency is underestimated because biliary tract disruption with concomitant vascular injury has been poorly studied and is currently underreported. Coronary computed tomography angiography studies should be performed on a routine basis to rule out concomitant arterial and portal interruption in cases of biliary tract disruption. Transferring patients to a specialized hepatobiliary surgery center or a tertiary referral hospital to ensure better short- and long-term outcomes is of paramount importance[15,16].

Conclusions

Biliary vascular injuries are one of the most serious complications associated with cholecystectomy. In our study, we concluded that they occur in 10% of the patients with biliary tract disruption, being right hepatic artery injury the ones most widely found in 87% of the patients (either in isolation or associated with another concomitant injury to a vascular structure). Ligating the right hepatic artery can be performed with a favorable prognosis in 73% of the patients. In our case, there was no significant impact on biliodigestive reconstruction when the proper technique was used (Hepp-Couinaud). Intentional screening for vascular injury using coronary computed tomography angiography is necessary, and suspicion should be raised due to its high frequency in cases of biliary tract disruption following cholecystectomy.

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Conflicts of interest

None declared.

Ethical disclosures

Protection of human and animal subjects. The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical research ethics committee and with those of the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors declare that no patient data appear in this article.

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