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Cover Page Footnote

This scientific material is part of a larger retrospective study of a PhD thesis, currently under development by Moldovan Cosmin, M.D., Ph. D. student at the Carol Davila University of Medicine and Pharmacy, Bucharest, with Prof. Vladimir Beliș, M.D., PhD., as thesis coordinator. The thesis has the following title: “Contributions to the forensic and legal study regarding the consequences of the iatrogenic lesions of the main biliary pathways occurred during the laparoscopic approach of hepato-biliary surgery”. All authors have read and approved the final manuscript and also declare no conflicts of interest.

Research Article

An evidence based guide to a safe intraoperative approach of avoiding iatrogenic lesions during difficult laparoscopic cholecystectomies

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Abstract **Introduction:** Although there are many sources for iatrogenic lesions during laparoscopic cholecystectomy, only a few stand out as being one of the most difficult to predict due to their nature of being very hard to diagnose before surgery. **Materials and Methods:** a short guide of cases with an evidence-based approach to avoid laparoscopic iatrogenic lesions. **Results:** these cases have been classified and presented into 3 main groups: cases with abnormal arterial layout, cases with heavy alteration of the normal anatomy, and cases with anomalies of the main biliary pathway. **Conclusions:** while not a complete guide covering all aspects of intraoperative traps during laparoscopic cholecystectomy, this series of cases points out some dangerous situations and some simple solutions to avoid those fiercely iatrogenic lesions of the ductal and vascular landmarks associated with an otherwise simple surgical intervention that has become the golden standard of the gallbladder lithiasic pathology.

Keywords: laparoscopic, cholecystectomy, iatrogenic, lesions, intraoperative, guide



Introduction

The problem of iatrogenic lesions during laparoscopic cholecystectomy (LC) is both a very old and an ever-contemporary problem in the general surgery community. In the United States, yearly, there are about 750.000 registered cholecystectomies (1), while in England the figure is close to 50.000 (2, 3). The German health system registers as many as 170.000 cholecystectomies from which 156.000 are performed by the means of laparoscopic approach. Out of those, 9.000 required intraoperative conversion to open approach and no less than 969 cases had the misfortune of being labeled as iatrogenic accidents due to ductal and/or vascular lesions. More so, 237 cases have been registered as severe choledochal accidents that correspond to a figure of 0.5% total complications rate (4).

This ceiling of 0.5% seems to be a common ground through the recent literature, many other authors (Strasberg et al.) reaching the same conclusions on a 125.000 patients study and warning about the rise of these complications from the era of the open approach from 0.1% - 0.2% to 0.4% - 0.7% (5-7). However, other authors (Savassi-Rocha et al.) conclude, from a very large study of patients conducted in Brazil (more than 90.000), that these complications are far lower, close to 0.018% (registering just 167 ductal and vascular lesions out of 91.232 cases).

As controversial as these figures may be, the problem at hand – ductal and vascular lesions during laparoscopic cholecystectomy – has risen with the advent and widespread use of LC and no matter the percentage, the sheer numbers of cases, in an absolute parameterization, are high, thus placing this operative complication among the top concerns of surgical teams

performing LC on a routine level, both in primary and referral clinics.

Materials and Methods

From our experience that stretches over more than 20 years of laparoscopic approach to the gallbladder pathology, we selected several difficult situations in which any surgeon, no matter the level of operative experience, must pay close attention, as these can rapidly lead to some very difficult to manage iatrogenic lesions with unpredictable short and long term outcomes.

These 9 cases have been classified and presented according to the following 3-fold criteria: cases that employed anomalies in arterial disposition (including here both anatomical variations as well as aberrant trajectories due to the inflammatory processes); cases where we encountered anatomical rearrangements due to the advance in local pathology; and cases that exhibited anomalies of the disposition and trajectory of the choledochal duct. Out of these 9 cases of laparoscopic cholecystectomies, eight ended up in a laparoscopic manner while one required conversion to an open approach.

Results

1. Anomalies in the arterial disposition

In this regard, we present a case of a laparoscopic cholecystectomy for acute lithiasic cholecystitis during which we have been confronted with a dual, symmetrical disposition of the Cystic Artery (CA), with one branch on each side of the cystic duct and with very close diameters in size. In this case one could easily be fooled by this particular disposition and an arterial transection could be registered with unpredictable results (*Figure 1*). The solution was to continue the dissection of the peritoneum further, more in a downwards disposition to reveal the joined trunk of the two arterial branches and

the decision to continue, prior to clipping, the dissection on the right side of the gallbladder in order to completely expose the mirrored trajectory of the second arterial branch. After clipping these two branches just before their forking point, the dissection proceeded in a normal fashion.

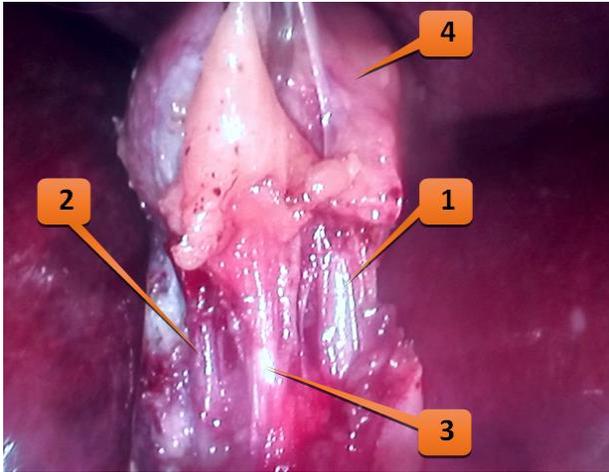


Figure 1. A double symmetrical disposition of the Cystic Artery. 1) Cystic Artery in its anatomical position; 2) The secondary CA, with an identical caliber, on the right side of the cystic duct; 3) Cystic duct – normally calibrated; 4) The gallbladder.

The second case of a rare arterial disposition was a spiral trajectory of the CA, with its starting point on the left side of the cystic duct, an upwards direction with anterior crossing of the duct and finishing on its right side, in a very high point and with a subsequent trajectory in the thickness of the gallbladder wall. To complicate things even more, the diameters of those two structures were comparable and thus a differentiation through laparoscopic palpation was very difficult indeed, giving virtually no tactile feedback (*Figure 2*). So, was this situation a possible case for an iatrogenic postoperative lesion? Yes, in several different scenarios, such as:

- Skidding of the clip from the proximal stump because of clipping in block the two structures – the cystic artery and the duct – in the event of a postoperative hypertension that in turn leads to a grooving pressure in the arterial stump that can lose the

grip of the clipping force and thus causing an incomplete sealing fibrosis at this level;

- The artery, which in this scenario would be placed medially, the clipping pressure is smaller on the outer end of the clip, exactly where the cystic duct is and therefore not providing the optimal external pressure for a perfect seal and thus leading to a potential permeabilization of the cystic stump.

Both scenarios have a possible ending with a choleperitoneum, a tremendous complication that not always can be recognized in the first 24 h of postoperative development and with unpredictable outcomes in terms of clinical evolution, even if prompt surgical treatment is applied.

The solution to this matter was, once again, the return to the basic principles of laparoscopic surgery: a careful dissection until we could identify every anatomical structure and then clipping each of them individually.

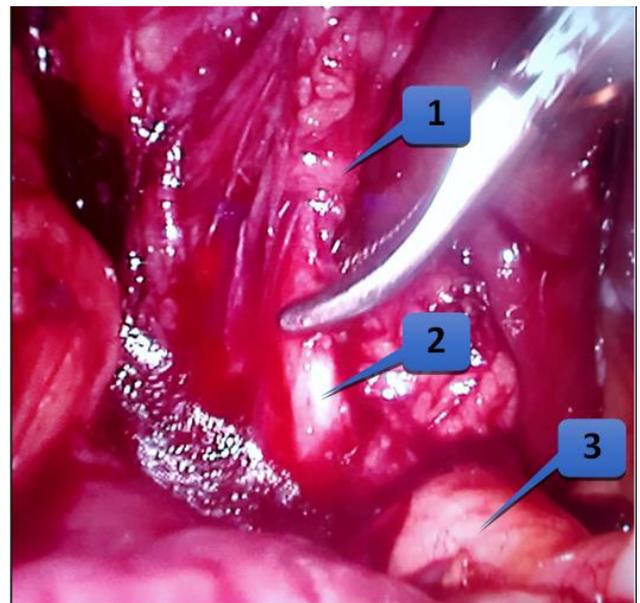


Figure 2. 1) Cystic duct in normal anatomical position; 2) CA with an identical caliber and a spiral anterior disposition; 3) MBP with an enlarged caliber.

The third case is about an interesting situation, often encountered during LC, namely a cystic artery, arranged as a complete arch with two redundant blood

supplies. More so, this arterial arch was arranged on the left side of the cystic duct, just where the normal cystic artery one would expect to find. Part of this arch – the cranial segment – had an ascendant trajectory and to the medial side, probable heading towards the hilar structures; the second segment – the distal and lateral one – was in the expected position of a normal cystic artery. We were facing therefore a true vascular anastomosis, with both ends being under constant blood pressure (*Figure 3*).

Could this have been a potential candidate for an iatrogenic lesion?

Yes, and the scenario could have played out in the following manner: as the usual approach in dealing with a standard disposition of a cystic artery is to place a clip on the proximal end and to apply the electrocautery on the distal end, the one that with go away with the rest of the gallbladder's body. However, this approach could lead to a possible bleeding source from the distal end, in this case being a still-active and under pressure site, susceptible to opening under a higher blood pressure in the postoperative stage.

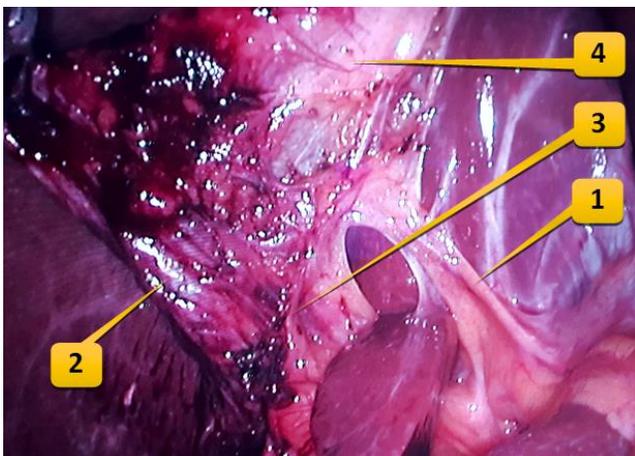


Figure 3. Particular disposition of the CA with an arch-like trajectory and redundant supply at both ends. 1) The trajectory of the arterial arch; 2) Cystic duct, in normal position; 3) The normal trajectory of the Cystic Artery; 4) The gallbladder.

How did we avoid such a scenario? By a complete and thorough dissection of the entire trajectory of the arterial landmark with proper visualization of both ends of the arterial arch and therefore choosing to clip both its stumps – the cranial and the caudal one as well (8).

But perhaps the situations in which an abnormal disposition of the Right Hepatic Artery (RHA) is involved are, by far, the most dangerous ones, especially that, without proper arteriographic equipment they are almost impossible to detect through a standard dissection technique.

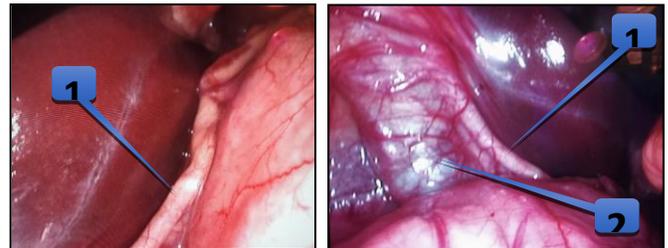


Figure 4. A rare case of RHA trajectory and disposition. 1) RHA with a horizontal disposition, embedded in the lesser epiploon; 2) Cystic duct, greatly enlarged. Image obtained with the use of a 30-degree lateral view endoscope.

We came across such a case when the trajectory of the RHA was a leveled one, going through the superior margin of the lesser epiploon and with a subsequent ascendant pathway towards the left margin of the cystic duct – this being enlarged as well, due to an intense process of lithiasic migration (*Figure 4*).

Could this have been a case of misidentification between the two structures?

Yes, in most cases, but, the solution to avoiding these kinds of misinterpretations is the use of a broad view-endoscope (at least 30-degree angle), in accordance with the recommendation of many authors such as Hunter (9) or Ungureanu et al (10). These kinds of endoscopes offer the best wide-area coverage and therefore a surgeon has a very good peripheral view of both the start and the end of the anatomical structures that lie ahead. As such our surgical team employs on a routine basis the Hopkins II™ 30 degree endoscope from Karl-Storz™.

Other situations that can lead to a potential hazardous postoperative setting are those where the left margin of the gallbladder registers multiple arteries with a “comb teeth”-like disposition which, under normal conditions of being small in diameter, poses no real threat to a normal postoperative outcome. However, we come across multiple arteries with a significant diameter and a parallel disposition approaching the right margin of the gallbladder, and in this case the better solution is to dissect and to clip each and every one of them, individually, thus minimizing the risk of postoperative bleedings (*Figure 5*).

More so, in the category of “common mistakes,” we can include those in which we have a large cystic artery with a “Y” shaped disposition and a right-side arrangement, a situation less common and thus often receiving less attention by the surgeons. In these scenarios we tend to clip the most obvious anatomical landmark at hand – the ascendant branch of the artery – and afterwards, as the dissection progresses on the left and the right side of the gallbladder, to forget, once we encounter the right branch of the above depicted arrangement of the cystic artery, that this one may in fact branch out under the previous placed clip and as such, just an electro-dissection is not enough as it may lead to a sudden retraction of the proximal arterial stump well into the hilar space making the search for it very difficult and prolonging the operative time well above the standard. Moreover, even if a temporary seal of the arterial stump is achieved by the standard use of the electrocautery device, this is far from the ideal technique of electro-dissection of an arterial landmark and may lead to a potential bleeding source in the postoperative period. Even if this is not the case of a typical iatrogenic lesion of the MBP – as there are no classifications of just the arterial landmarks in any current systems cited in the literature – this is can be very difficult clinical situation

to manage with some very unpredictable outcomes that must be avoided at all costs (*Figure 6*).

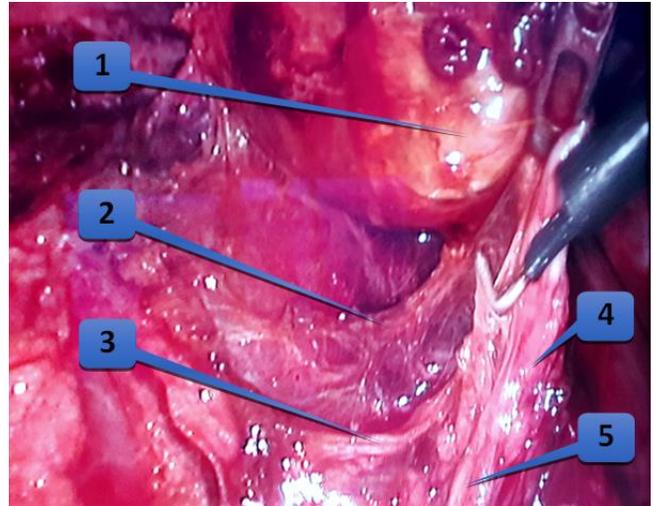


Figure 5. Multiple parallel arterial sources. 1) Gallbladder; 2&3 Multiple arterial sources with a direct output from the liver; 4) Cystic duct; 5) Cystic Artery.

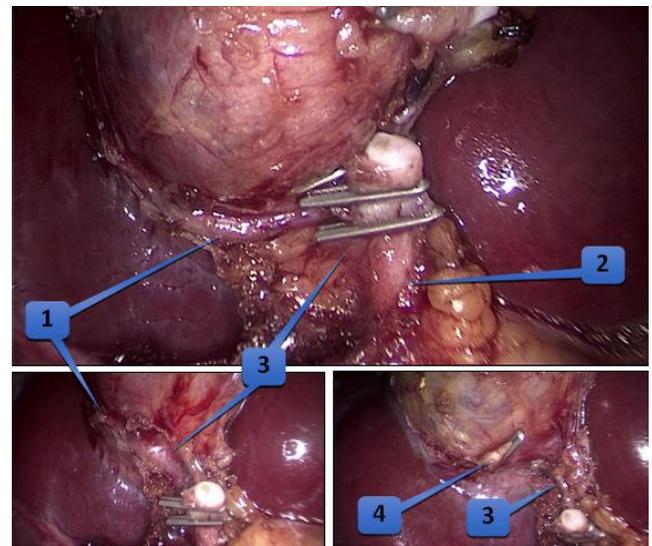


Figure 6. A particular disposition of the CA with 2 equal “Y” branches and a high setting of the RHA. Legend: 1. Right branch of the CA; 2. Cystic duct with 2 titanium clips (to the proximal end); 3. The main body of the RHA; 4. A high clipping of the right branch of the CA.

2. Anatomical rearrangements due to the advance in local pathology

Perhaps the most dangerous traps in LC are laid by modifications in trajectory, disposition and aspect to the normal anatomical structure by the inflammatory and

sclero-atrophic processes that take a natural part in the evolution of the pathology of an acute or chronic inflammation at the level of extrahepatic biliary tree.

In this regard, we came across a case in which an intense process of pediculitis with a heavy rearrangement of all anatomical planes that led to a complete atypical picture at the end of the dissection in the expected position: a rather large structure with a ductal-like aspect that did not allow us to dissect it further, due to the very important wall edema. At the first glance, its proximal end was going straight into the gallbladder and the distal one had a trajectory most probable for the hilar area of the liver but in the thickness of this structure a second one could have been very easily hidden. And indeed, this was the case, as we discovered a very long MBP with a loop arranged in a 180-degree manner that was going up, made a sharp bend and took a downwards disposition after in the same narrow space, giving the overall impression of a single structure that could pass as an enlarged cystic duct. Clipping this landmark and sectioning it above, just like in the normal fashion, would have led to a text-book like Hamburg B2 iatrogenic lesion.

Our solution was a partial (incomplete) cholecystectomy in a high position well above the expected end point of the bended MBP and sealing the stump with a surgical thread and an extra-abdominal knot (*Figure 7*).

But is it safe just to visualize the cystic duct on just the front side?

Well, the complete answer is no. The fact that the surgeon sees the cystic duct just on one or two (anterior and lateral or medial plane) of its sides does not place him in a safe position to ensure a lesion-free placement of the clips. The anatomo-clinical situation depicted above, where the cystic duct is enlarged and very short,

behaving like a true fistula among the gallbladder and the choledocus along with a bended and twisted MBP that has been retracted upwards by the scleroatrophic processes, can lead to a potentially dangerous situation, when clipping the cystic duct in a very low disposition can “pinch” the apex of the sharp bend of the MBP and thus inducing a typical E3 Strasberg-Bismuth, a level III Stewart-Way or Hamburg B2 lesion. This lesional mechanism is also known as “tenting” the MBP and has been described by many authors such as Kune et al, (11) or Lau et al (5).

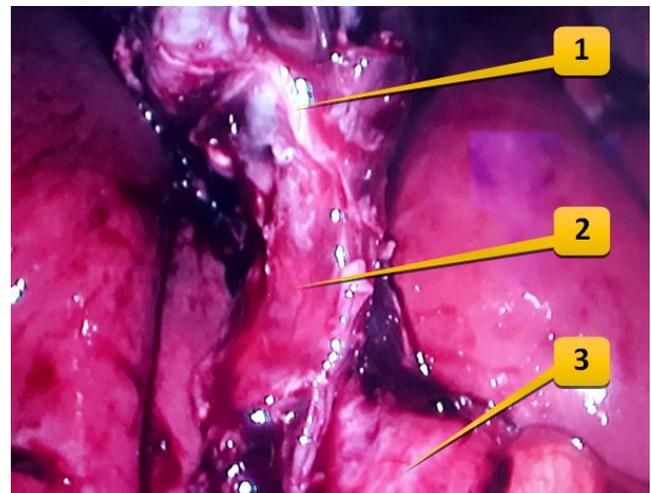


Figure 7. LC for acute lithiasic cholecystitis that reveals an infundibular area with an important edema and major anatomical rearrangement of the normal planes. Legend:1. Gallbladder; 2. The infundibulo-cystic area; 3. Enlarged MBP due to repeated passage of small shaped calculi.

The only safe way to avoid this kind of situation is to try to dissect in a 360-degree manner the cystic duct, to correctly identify its level of junction with the MBP by using a 30-degree endoscope that allows the surgeon a very good view of the structures (*Figure 8*).

3. Anomalies of the disposition and trajectory of the choledochal duct

Even though there are no scleroatrophic induced disagreements of the anatomic planes, sometimes dissecting the structures in the expected fashion can be very difficult, and this is the case of abnormal

dispositions of the choledocus, which are less rare than one would expect.

This is the case of a patient whose clinical behavior and laboratory data did not flag for an atypical case and thus we had no reason to perform a preoperative cholangiography. But the intraoperative exploration led us wishing we had. After a very difficult dissection on the left wall of the gallbladder we discovered a choledocus with loop-like disposition with 2 segments, one going upward and the other going downward, in very close proximity with the infundibular area and thus making the differentiation process between the two very difficult, and so leading to a potential confusing situation in which a complete transection of the MBP was very possible (Figure 9).

Discussions

As stated before, the problem of ductal and vascular lesions during LC represents a very serious problem that should not be taken lightly. As highlighted by numerous studies over the last decades (Table 1), out of the many complications encountered during LC, the ductal and vascular ones are far the most common and, unfortunately, the most difficult to assess and often with questionable outcomes on the long run, despite the best surgical options chosen.

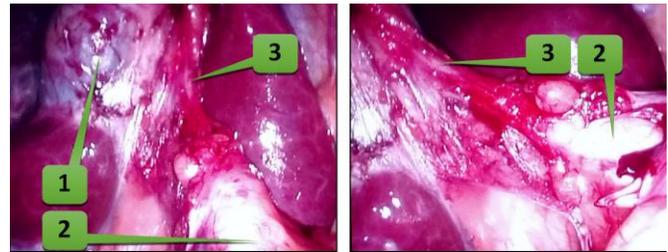


Figure 8. A combination of an enlarged MBP (due to repeated passing of calculi) with a short and thick cystic duct – an equivalent of a fistula between the gallbladder and the MBP. 1) Gallbladder; 2) MBP with a 3 times larger diameter; 3) The cystic duct.

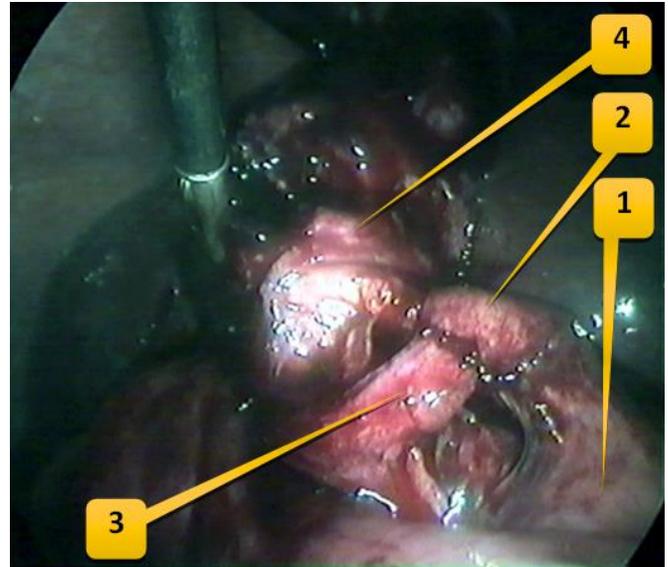


Figure 9. An abnormal disposition of the choledocus with an ascending loop towards the infundibular area. 1) Enlarged MBP; 2) The ascending segment of the choledochal loop; 3) The descending segment of the choledochal loop.

Table 1. Distribution of the iatrogenic lesions registered during LC. A meta-analytic study of the available literature.

Study	Year of First Publication	Location for Case Selection	No. of Cases analyzed	Types of lesions involved			
				Vascular	Ductal	Intestinal	Other
Malpractice Insurance Association of USA	1994	SUA	324	9 %	70 %	11 %	10 %
Kern	1997	SUA	44	9 %	61 %	9 %	14 %
McLean	2006	SUA	104	7 %	78 %	2 %	13 %
De Reuver et al.	2008	Holland	210	n/a	62 %	n/a	n/a
NHSLA	2014	UK	133	3 %	72 %	9 %	16 %

More recent studies (12, 13) conducted on very large numbers of patients (close to 1.6 million cholecystectomies) have shown that, despite the fact that the learning curve of the LC has been overcome and thus has leveled, in the mid-90s, against expectations, the

iatrogenic lesions chart remained at the same level, 0.5%, and has not decreased dramatically, as expected, nor is it showing any signs of decreasing any time soon.

Why is that? Many theories have been advocated, and among the most well accepted is the ever-increasing

confidence of the surgeons performing LC with many of them pushing the indications of the method well beyond its limits, forcing dissection where normally one should convert the approach to open surgery. Others place this problem on the disregard of the basic principles of laparoscopic dissection that many surgeons, once gaining sufficient experience, drift apart from, a dangerous affair even in cases that lack the anatomical reconfigurations induced by heavy scleroatrophic or inflammatory processes.

This is the situation depicted in the series of cases presented in this paper and, despite the lack of preoperative or intraoperative cholangiography in some cases (this investigation was not always available during surgery in our clinic, due to intermittent technical problems) we found practical solutions to the matter at hand, thus avoiding some heavy damages to the MBP and/or the arterial landmarks nearby with catastrophic consequences on the long and short run, especially in the management of the patient but also in malpractice claims.

Regarding the vascular injuries recorded during LC, these are perhaps the most unpredictable causes of iatrogenic lesions as very few cases diagnosed with lithiasic pathology undergo an arteriography exam prior to surgery and even if this equipment is available in the surgical clinics the investigation itself has very focused indications. Routine angiography in the preoperative stage for the laparoscopic gall bladder removal has been debated for a long time and by various surgeons but a common ground has not yet been achieved. The main reasons that many authors are not recommending this procedure are high costs (due to very specialized personnel, dedicated imaging devices, etc.), some certain steps necessary for patient preparation (that prolongs the perioperative time spent) and the not-so-neglectable complication rates closely related to the procedure itself. Moreover, recent studies – comparing the imaging

findings obtained prior to the surgical procedure and matching them with the incidents recorded during the surgery - suggest that even with the aid of an arteriography some arterial lesions could still not be foreseen. This being said, some authors, such as Jie Dai et al. (14), are strong advocates of this method and their published papers back their claims with strong numbers that are hard to overlook. In his study, on more than 600 patients with routine preoperative selective hepatobiliary angiography, the authors discovered that in 20% of the cases the vascularization for the main biliary pathway is comprised of branches arriving from both Posterior Portal Artery and Hepatic Artery, along with the classic disposition from cranial and caudal sides, thus explaining some major arterial loss that we can encounter sometimes during surgery.

But how to avoid these types of arterial complications, during surgery, when we come across a complicated local anatomy and we do not have the back-up of an arteriographic investigation? Again, we must always be faithful to the basic principles of laparoscopic dissection.

Conclusions

This material is not intended in any case to be a comprehensive and all-knowing reference for every type of scenario that can lead to a potential iatrogenic lesion of the MBP during LC, but rather a short and concise walk through the most common cases of potentially difficult situations that we encountered in OR and managed to overcome in various ways, either employing advanced imaging or using just plain good surgical sense and observation.

We consider the use of intraoperative cholangiogram a very good option in any case in which identifying the correct anatomical landmarks is difficult and while it may add some time to the overall length of the surgical procedure, it can outline the proper layout of

the ductal structures and more so, place the surgeon in a safe and legal position in case of an iatrogenic lesion. Although there is still a legal debate and courts all over the world continue to rule differently when it comes to iatrogenic lesions registered even if cholangiography was performed during surgery (15), it clearly shows that the surgeon has gone the full length of his abilities and judgment to perform at his best in order to avoid an iatrogenic lesion when confronted with uncertainties.

Regarding the use of routine preoperative cholangiogram, we consider this option – despite the large experience and positive results recorded by Kurumi et al. (16) – a very heavy-on-resources and personnel, expensive and time consuming procedure as well as a potential source of complication right before surgery. Therefore, we do not advocate its use on a routine level but rather on a step-wise approach with a strict clinical-based evidence indication.

The best options for avoiding complications – both ductal and vascular – during LC are to employ the very simple and cost effective basic rules of laparoscopic surgery, such as:

- never approach a dense and compact landmark full frontal;
- limit the use of the electrocautery device in close proximity with ductal, vascular and cavitary organs;
- never cut or clip structures that you do not have a visual confirmation about: its origin, distal end, projected trajectory;
- always perform the dissection as close to the gallbladder wall as possible;
- never clip a structure that the clip cannot over exceed;
- always perform a intraoperative cholangiography (if available) to clarify those uncertainties regarding the ductal structures.

Perhaps the most obvious but also the most difficult to implement due to the intrinsic human nature of avoiding to place oneself in a lesser position, a

characteristic well developed in surgeons, always ask for a second opinion wherever in doubt about the landmarks ahead, preferably a hepato-biliary expert that may bring a fresh and unbiased opinion during surgery and provide a feasible solution in avoiding an iatrogenic lesion.

Acronyms and abbreviations

LC: laparoscopic cholecystectomy; CA: Cystic Artery; MBP: main biliary pathway; RHA: right hepatic artery; CD: Cystic Duct; OR: operating room.

Acknowledgements

This scientific material is part of a larger retrospective study of a PhD thesis, currently under development by Moldovan Cosmin, M.D., Ph. D. student at the Carol Davila University of Medicine and Pharmacy, Bucharest, with Prof. Vladimir Beliș. M.D., PhD., as thesis coordinator. The thesis has the following title: “Contributions to the forensic and legal study regarding the consequences of the iatrogenic lesions of the main biliary pathways occurred during the laparoscopic approach of hepato-biliary surgery”. All authors have read and approved the final manuscript and also declare no conflicts of interest.

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