

# Anatomske variacije cistične arterije: primerjava korozivnih jetrnih preparatov z laparoskopskimi holecistektomijami

## Anatomical variations of the cystic artery: comparison of corrosion liver casts and laparoscopic cholecystectomies

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**Izvleček**

**Namen:** Natančno poznavanje izvora cistične arterije je pri izvajanju varne laparoskopske holecistektomije za kirurga temeljnega pomena. Klasifikacija izvora cistične arterije je tema številnih člankov, ki skušajo različne anatomske variacije razdeliti s pomočjo informacij, pridobljenih s številnimi laparoskopskimi holecistektomijami. Namen te študije je ugotoviti točnost in uporabno vrednost podatkov, objavljenih v člankih, ki se pri klasifikaciji anatomske variacije cistične arterije opirajo zgolj na rezultate, pridobljene z laparoskopskimi metodami.

**Metode:** Arterijsko preskrbo žolčnika smo preučevali pri 220 bolnikih, pri katerih je bila napravljena laparoskopska holecistektomija. Rezultate smo primerjali z našo starejšo študijo na 81 kadaverskih jetrih. Rezultate smo nato primerjali še z rezultati študij drugih avtorjev.

**Abstract**

**Purpose:** Thorough knowledge about the origin of cystic arteries is very important for carrying out safe laparoscopic cholecystectomy. Numerous studies have tried to classify its origin based on carrying out laparoscopic cholecystectomies. We tested the accuracy of similar studies that classified anatomical variations of the origin of the cystic artery based on laparoscopic cholecystectomies.

**Methods:** We studied the arterial supply to the gallbladder in 220 patients treated by laparoscopic cholecystectomy and compared it with our older study of 81 livers removed from cadavers. We also compared our results with those of similar studies.

**Results:** The study revealed many anatomical variations. Different variations were divided into three groups: Calot's triangle type, outside Calot's triangle, and compound type. Some of

**Rezultati:** Pri študiji smo odkrili mnogo anatomskih variacij. Le-te smo razvrstili v tri skupine: tip "Calotovega trikotnika", tip "izven Calotovega trikotnika" in sestavljen tip. Nekateri rezultati, pridobljeni v študiji, so bili primerljivi z rezultati drugih, podobnih študij, drugi rezultati pa so se bistveno razlikovali.

**Zaključek:** Menimo, da je sama laparaskopska kirurgija kot takšna neprimerna metoda za določanje anatomskega izvora cistične arterije.

*our results were comparable with other similar studies, but others were not.*

**Conclusion:** We found laparoscopic surgery itself to be an unsuitable method for determination of the anatomical origin of cystic arteries.

## INTRODUCTION

Laparoscopic cholecystectomy is widely accepted as the "gold standard" in the treatment of cholelithiasis (1-4). However, it was initially associated with a significant increase in morbidity (5). Higher morbidity was usually explained by insufficient knowledge of the laparoscopic view of the anatomy of the gallbladder pedicle. Thorough knowledge regarding the origin of the cystic artery is therefore extremely important, particularly if intraoperative bleeding occurs in the gallbladder fossa because it increases the rate of conversion to open surgery (6). The laparoscopic surgeon must therefore be aware of the possible arterial and biliary variants. Variations in the origin, position and number of cystic arteries (as well as those of the biliary tree) are quite common (7, 8). They are found in 25-50% of cases (7, 9-11).

We investigated the appearance of the cystic artery during laparoscopic cholecystectomy and tried to compare our findings with the results acquired in our earlier study. That study was published in 2003; we studied the anatomy of the cystic artery in corrosion casts of macroscopically undamaged livers which were removed during autopsies from individuals without a history of liver disease (6). Both studies (corrosion casts as well as laparoscopic cholecystectomies) were done in the same, Slovenian population.

## MATERIAL AND METHODS

A retrospective evaluation of 220 non-emergency patients who underwent laparoscopic cholecystectomy was taken. Laparoscopic cholecystectomy was carried out under general anesthesia using the four-ports technique. Information regarding Calot's triangle and distribution of the cystic artery on endoscopic visualization was recorded. The anatomical structures were viewed on a three-dimensional video monitor. We compared our results to the study of 81 livers published in 2003 (6). The arterial system of the gallbladder was analyzed in 60 corrosion casts and 21 livers removed from embalmed cadavers.

The anatomy of the cystic artery was classified into three groups as described by Ding et al (5). Classifying our findings from corrosion casts into the three major groups proposed by Ding et al. was very difficult because the classification was created for the laparoscopic view (5). However, we assumed that in those cases where "classical anatomy" was found (single or double cystic artery originating from the right hepatic artery (RHA), there was a very high probability that the cystic artery was inside Calot's triangle. We also classified our findings according to the subgroups described by Ding et al. (5).

## RESULTS

We classified the anatomy of the cystic artery into three groups as suggested by Ding et al., as detailed below (5).

### GROUP 1

Group 1 represented the Calot's triangle type, in which the cystic artery passes through Calot's triangle. Group 1 was further subdivided into two subtypes as detailed below. This was the commonest type.

We found this type in 200 patients (90%) out of 220 cases during laparoscopic cholecystectomy; 174 had a single cystic artery (79%) and 26 that had a double cystic artery (11.8%). In one case, during laparoscopic cholecystectomy, we even found a triple cystic artery originating from the RHA.

In our study of corrosion liver casts and livers removed from cadavers, a cystic artery originating from the RHA was found in 48 out of 81 livers (59.3%); 42 of which had a single cystic artery (51.9%) and 6 that had a double cystic artery (7.4%). There were 15 cases (18.5%) of cystic arteries originating from the right anterior sectional artery (ASA). This is a branch of the RHA and can also be found inside Calot's triangle if it separates from the RHA early. Hence, 63 cases (77.8%) of cystic artery anatomy could be classified as Calot's triangle type.

#### Classical single cystic artery

In this subgroup, the cystic artery originates from the RHA within Calot's triangle. When approaching the gallbladder, the artery is divided into deep and superficial branches at the neck of the gallbladder. The superficial branch proceeds along the left side of the gallbladder. The deep branch runs through the connective tissues between the gallbladder and liver parenchyma. In the present study, we found this type in 174 of 220 patients (79%) during laparoscopic cholecystectomy.

In our study of livers removed from the cadavers, we found this type of anatomy in 55 cases (68%). A single cystic artery originating from the RHA was found in

42 liver casts (51.9%). In 13 cases (16.1%) a single cystic artery originated from the right ASA.

#### Double cystic artery

In this subgroup, two cystic arteries originate from the RHA within Calot's triangle. This type of anatomy was found in 26 cases (11.8%) during laparoscopic surgery and in 8 corrosion liver casts (9.8%). In 6 corrosion liver casts (7.4%) the branches originated from the RHA, in two cases (2.4%) the arteries originated from the right ASA.

### GROUP 2

In this group, the cystic artery approaches the gallbladder outside Calot's triangle and cannot be observed within the triangle by laparoscopy during dissection. This group includes four subgroups.

During laparoscopic cholecystectomy we found 16 patients with such anatomy (7.3%). However, our study on corrosion casts and livers removed from embalmed cadavers showed this type of anatomy in 28 cases (34.5%).

#### Cystic artery originating from the gastroduodenal artery

In this subgroup, the cystic artery does not pass through Calot's triangle but approaches the gallbladder beyond it.

This type was found in only one case (0.45%) during laparoscopic cholecystectomy. A cystic artery originating from the gastroduodenal artery was not found in any of the 60 corrosion casts and 21 livers from embalmed cadavers.

#### Cystic artery originating from the variant RHA (replacing or accessory to the RHA)

In this subgroup, anatomical variation of the RHA usually originates from the superior mesenteric artery or aorta. It enters Calot's triangle behind the portal vein.

In the present study, we did not find any cases of such anatomy during laparoscopy. However we found 1 single and 11 cases of a double cystic artery originating from the hepatic artery (5.45%).

In comparison, a cystic artery originating from a variant RHA was found in 3 corrosion liver casts and 3 livers removed from embalmed cadavers (7.4%).

#### **Cystic artery originating directly from the liver parenchyma**

In this subgroup, the cystic artery pierces the hepatic parenchyma approaching the bladder from the gallbladder bed. During laparoscopic cholecystectomy, we recorded 3 patients (1.4%) with such anatomy.

However our study of corrosion liver casts showed different results. We noticed 3 cases (3.7%) in which the cystic artery originated from subsegment arteries for V, VI and VIII liver segments. We also found 4 cases (4.9%) where the cystic artery originated from the right posterior sectional artery (PSA). However, we could not say for certain that these arteries originated from the liver parenchyma.

#### **Cystic artery originating from the variant left hepatic artery (LHA) (replacing or being an accessory to the LHA)**

In this group, the cystic artery occasionally originates from the LHA, passes through the liver parenchyma, and reaches the middle of the gallbladder body, at which point it bifurcates into ascending and descending branches.

This anatomical variation was not found in any of our studies, neither during laparoscopy nor in the corrosion casts.

### **GROUP 3**

#### **Compound cystic artery type**

This group has more than one blood supply. The cystic arteries exist not only in Calot's triangle, but also outside it.

This anatomical variation was not found in the present study during laparoscopic cholecystectomy, but we found 3 (3.7%) such cases during analysis of our corrosion liver casts. In 2 of this cases (2.4%) one cystic artery originated from the RHA and another from the right ASA. In 1 case (1.2%), one cystic artery originated from the RHA and the other from the LHA.

In two cases during laparoscopic cholecystectomy, we could not define the anatomy of the cystic artery due to inflammation and gangrene.

## **DISCUSSION**

Thorough knowledge of Calot's triangle and the origin of the cystic artery is important for conventional as well as for laparoscopic cholecystectomy (5, 6, 12). Visualization of anatomical structures during laparoscopic cholecystectomy is a prerequisite for carrying out safe laparoscopy because anatomical relationships are seen differently during laparoscopic and conventional surgery. It is well known that anatomical variations of the origin of the cystic artery are very frequent.

We tested the accuracy of similar studies that classified anatomical variations of the cystic artery based on laparoscopic cholecystectomies. Many different studies describe the anatomy of the cystic artery. All have different classifications and different percentages of anatomical variations. These results are not very reliable because accurately defining the anatomy during laparoscopy can be very difficult.

Different results could also be interpreted due to different authors with different subjective views of anatomy or even due to different groups of patients. In our study, however, the person who worked with corrosion liver casts and livers removed from embalmed cadavers also carried out the laparoscopic cholecystectomies. Nevertheless, the results were very different.

The reason for such results are the limitations of both methods. Defining even the number of arteries during laparoscopic cholecystectomy can be very difficult. When the cystic artery is found in front of the cystic duct in a laparoscopic view, there is often another artery behind it. However, one of the visible vessels could also be a vein. Pulsations can be conducted from arteries to veins. This can lead the surgeon astray in his/her attempt to identify cystic arteries. This is only one of the obstacles that reduces the value of laparoscopy as a method for defining anatomical relationships. Another problem is due to different interpretations.

One surgeon (or a group of surgeons) could decide that what they see at laparoscopy is one type of anatomy, but at the same time another group could decide differently. This was the case when we did not find any cases of a cystic artery originating from a variant RHA during laparoscopy. In comparison, Ding et al. found this type of anatomy in 3% of cases. However, we found 12 cases of cystic arteries originating from the hepatic artery (5.45%)—a type of anatomy not described by Ding et al. However, a cystic artery originating from a variant RHA was found in 3 corrosion liver casts and 3 livers from cadavers (7.4 %) during our first study.

Unless a conversion to conventional cholecystectomy is done (where the origin of the cystic artery is seen clearly) it is hard to be sure about its true origin. Therefore, a study on corrosion liver casts would, in our case, be a much more suitable method for defining the true origin of cystic arteries. However, this method also has disadvantages. One of them could be seen in group 2 (cystic artery originating directly from the liver parenchyma) where, while analyzing the corrosion liver casts, we found 4 cases in which the cystic artery originated from the right PSA and it was practically impossible to say if these arteries originated from the parenchyma. This is because the parenchyma is destroyed during the casting process as the specimens are placed in 30% HCl solution and after a few days the necrotic tissue is rinsed away with water jets. This is probably the reason why the results acquired from laparoscopic cholecystectomies and corrosion liver casts are so different in this group.

We also found 15 cases of cystic arteries originating from the right ASA, which is a branch of the RHA. The right ASA can also be found inside Calot's triangle if it separates from the RHA early. However, because these 15 cases were found in our liver casts, we cannot be certain if these arteries would be found, in laparoscopic view, inside Calot's triangle or outside it. But then again, the laparoscopic view could never uncover their true origin because it would be almost impossible to tell if they originate from the right ASA or RHA.

Dissection of formaldehyde specimens is probably the best method for determination of anatomical structures (especially for large vessels), but even this method has disadvantages because small vessels (e.g., cystic arteries originating from the ASA or PSA) which originate directly from the liver parenchyma are easily overlooked.

In conclusion, laparoscopy has numerous advantages and benefits but it cannot be used for defining anatomy, nor is that its purpose. Therefore, carrying out studies on the multitude of different types of cystic artery anatomies and debating about different percentages in which one type of anatomy is present in the general population is not worthwhile. The results of all studies clearly show that the commonest type of anatomy is the so called 'classic type', i.e., a cystic artery originating from the RHA inside Calot's triangle. However, this is far from being the only type of anatomy.

For a surgeon undertaking laparoscopic cholecystectomy it is important to ensure that the structure which he/she is about to cut enters the gallbladder directly and is not a hepatic duct. We propose that Calot's triangle should be dissected in such manner that it is free of all tissue except the cystic artery and cystic duct. When this is achieved, and the base of the liver bed is exposed, the two structures entering the gallbladder can only be the cystic artery and cystic duct.

Therefore, when undertaking laparoscopic cholecystectomy, knowledge of visualization of anatomical structures during laparoscopy is crucial. This can be best learned in laparoscopic workshops. It is also important to be aware that there is a great variety of anatomical variations of the origin of the cystic artery. That is the basis and essence for carrying out safe and effective laparoscopic cholecystectomies.

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