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ICG Infrared Laparoscopic Cholangiography–An Approach to 0% Bile Duct Injury

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Abstract

Cholecystectomy is the treatment of choice for gall bladder stone since centuries. Bileduct injuries are associated with cholecystectomy since beginning. In last three decades gall bladder removal by laparoscopy has superseded the open method but the incidence of bile duct injuries remained same especially with beginners. This is mainly dueto misinterpretation of anatomy at calot's triangle. The meticulous surgery for the gall bladder during cholecystectomy has prime role in prevention of bile ductinjury. We have recently use real time identification of bile duct during surgery by infra red method. This infra red technology has come in the way with more than 99% sensitivity in bile ducts identification. Indocyanine Green(ICG) is a florescent dye which is used for this purpose. Dye injected before operation is detected by a special telescope mounted on a high definition camera. This telescope emits infra red which detects ICG dye inside bile ducts. This helps in detection of biliary anatomy and prevents bile duct injuries.

Keywords: Laparoscopic Cholecystectomy; Bile Duct Injuries; Indocyanine Green Dye; Infra Red; Common Bile Duct(CBD).

Introduction

Laparoscopic surgery has now revolutionized many surgeries. This is now procedure of choice for many diseases. Laparoscopic cholecystectomy is now treatment of choice for gall stones worldwide. Since the beginning of cholecystectomy either open or laparoscopic, bile ducts injuries are associated with this. The incidence of bile duct injuries varies from 0.1% to 0.3% in different centers. This happens to be more with laparoscopic surgery especially with beginners. Many tips and tricks are advised to avoid this injury viz careful dissection of area of safety, making windows, presence of lymph node of Lund, dissection below Rouviere's sulcus, Intraoperative cholangiogram or ultrasonogram (USG) to identify biliary anatomy [6,7,9]. But in spite of these landmarks and precautions, biliary duct injury is a ground reality.

Dissecting area of safety becomes impossible if the anatomy is severely distorted. One can make window posterior to bile ducts and then clip and cut it. Rouviere's sulcus is absent in 20-30% of cases[10]. Intraoperative USG is not available readily, needs training and many laws behind it. Lymph node of Lund has not its constant position[6]. Intraoperative cholangiogram is time taking and many time leads to complications with cystic ducts and biliary leakage. It involves ionizing radiation also. However it is more valuable in detecting bile duct stones.

Bile duct injuries mainly occurred due to misinterpretation of anatomy. Recently infrared technology using a fluorescent dye indocyanine green (ICG) is advocated during laproscopic cholecystectomy (LC) with an approaching 0% biliary duct injury.

This is a very fast and most accurate method of detecting biliary anatomy and the image is caught by telescope to be displayed on a monitor.

Materials and Methods

Instruments

Present studyis done with the equipment developed by Karl Storz GmbH & Co KG, Tuttlingen, Germany. Recently Striker company has also launched its infra

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red ICG system. The instruments are the most advanced system with very clear vision. It has brilliant HD quality and contrast enhancement. It has inbuilt recording system. Recording is easy and control of recording is over camera head. Switch over from infrared mode today light mode is done with the help of a foot pedal. The life of infra red bulb is 300 hrs, as claimed by company. We have to change the bulb after completion of about 700 cases. Now when we cross the dissection of calot's triangle, we switch over to another normal light source. This is just to prolong the life of infra red bulb inlight source.

This system shows high resolution of near infrared real time images of bile flow in liver, bile duct and splanchnic system. The light needed for excitation of fluorescence is emitted by a near infrared light source which is later on caught by a camera mounted on special telescope and the image is displayed on a real time high resolution monitor. Peak spectrum of fluorescence is about 800 nm which is visible by infrared. Infrared is a type of electromagnetic wave as radio waves without any property of biliary injury. Human tissue is relatively transparent to infrared. Infrared is invisible but feel as heat.

Indocyanine Green (ICG) Dye

It is mainly used in ophthalmology for retinal angiography[4]. Its application is also to measure cardiac output and hepatic function. Other uses in surgery is to detect sentinel nodes detection in malignancy, intestinal surgery to assess vascular viability of anastomotic site, in plastic surgery, ulcer healing, diabetic extremities, aorta-coronary bypass etc. In urology, ureter can be seen, filled with dye with the help of ureteric catheter during endoscopic procedure. Here study is done for its specificity and selectivity in gall stone surgery only.

ICG is a fluorescent dye.When it is injected, it is rapidly taken by hepatocytes and excreted solely by bile. The fluorescence emitted by the dye is seen by infrared rays emitted by the special light source[2].

Once injected it rapidly gets bound with plasma proteins and remains confined to vascular system. It is well tolerated and removed exclusively by liver into biliary system. ICG is non radioactive.

Being a fluorescent dye, the absorption and fluorescent spectrum is near infrared region. The absorption of ICG is between 600-900 nm and fluorescence is between 750-950 nm. Depth of visualization is 1.5 cm. Duration of visualization in circulation after injection is 24 hrs. Laser beam of 780nm can also detect the fluorescence of dye. It has no metabolites.

Toxicity of ICG is low as it is not absorbed by intestinal mucosa. Whether it crosses the blood brain barrier, it is not clear. Intravenous lethal dose in experimental animals is 60-70 mg / kg body weight (bw) which is much above the dose of clinical use (0.1to 0.5 mg / kg bw). ICG dye is available in 25 mg pack which is diluted in 10ml of sterile water for injection. The dose of ICG for LC is around 12.5 mg to 19 mg total (5-7ml of dye). ICG solutions to be used within 10hrs of preparation. Prior skin sensitivity test is done in all cases. No untoward reaction is seen in any patient except slight discoloration of skin which persists for few days 2000 gallstones cases were operated till 15thDec 2017 with the help of this system. First case of LC on this system was done on 8th may 2015.Out of 2000 cases 1359 cases were female, rest were males. Pregnant women and children below 12 years were excluded from study.

Operation was done at variable times from 2 to 6 hrs of injections. All male patients are tried to get operated after 6hrs of infection. We had adopted a policy of giving prior injection of ICG dye in all patients who have LC. Most of LC cases are done within 3 hours of injections. We start with female cases first, later on male cases. If assumed difficult cases preoperatively either male or female, we prefer to spend at least 6 hrs after injections.

In few cases of female lap chole we injected the dye after making pneumoperitoneum to measure the least time to dye appearance in bile duct.

In cases of male patients where difficulty is anticipated a time interval of at least 6 hrs is elapsed after injection. However safe time interval of female patients with difficult calot's triangle is also to be evaluated, but we take more time when difficulties are anticipated.

Results

The fluorescence of ICG is typical milky blue appearance in infrared which is detected by camera. Bile ducts are recognized by its position, caliber and courses. Contrast illumination of liver did not post any problem in recognition of bile ducts in any case of our series.

All important structures including bile ducts like stomach, duodenum, liver, sometimes jejunum and ileum contains dye and gives fluorescence in infrared light. Only fascial tissue gives blackish appearance in infrared.

Nowadays stress is given over to dissect *triangle of safety* after dissection. Here triangle of safety is visible in infrared mode since beginning of dissection over calot's starts.

In all cases biliary ducts (Common Hepatic Duct (CHD), CBD, Cystic Duct (CD)) are visualized properly except in 15 cases. Out of these 15 cases,11 cases were male cases and 4 cases were females. One male case was of cholecysto-duodenal fistula. 2 cases were of

inoperable carcinoma. Rest 8 male and 4 female cases were of difficult anatomy at calot's triangle with wide spread adhesion and thick fibrous tissues. In 3 cases when we dissected fibrous tissue deeply faint visualization of dye is seen giving clue to bile duct. In all cases no bile duct injurieshappened.

Better visualization of dye seen if the time intervals are increased. Females are operated after 3-4 hrs but all males and suspected difficult female cases were operated after 6 hrs. However thin built male patients without acute attack can be treated as female patients and can be operated before 6 hrs of injection. We couldn't assess the maximum time of stay of dye between injection and full excretion of dye.

Cystic duct is visualized properly except in few cases where cystic duct is small caliber or absent. Dye is also seen in gall bladder when dye is seen in cystic duct. Fascia around calot's triangle gives typical black appearance in infrared mode which helps in separation from bile ducts. This is important as dissection is limited to these fascia sparing the bile ducts and cystic artery. Whenever confusion arises we switch over to infrared mode to see whether it is fascia or bile ducts.

The junction of cystic with CHD is clearly defined in infrared leaving no cystic duct remnants with future stump stones. Many times a long cystic duct present which remains hidden inside fascia. Just making a window after securing a area of safety is not sufficient. When seen in infrared whole length of cystic duct becomes visible leaving no room for cystic duct remnants with future stones. This is also one of the major advantages of infrared technology (Figure 1).

When Intraoperative dye is given to see the *Cysticarteriogram*, artery is filled with dye within one minute. Real time feeling of dye is seen in cystic artery in infra red mode. It persists for 2-4 minutes. Before doing arteriography it is insured that the field of vision should be dry. Any oozing vessel will take the colour of dye and obscure the artery. Arteriography is not done in every case but in difficult cases.Where anatomy of calot's triangle is not clear, it is preferable.

Every effortis made not to spillage of dye dueto rupture of gall bladder. If dye spread overcalot's triangle before dissection then purpose of infrared cholangiography becomes lost. Every tissue becomes fluorescence in infra red (Figure 2).

In few thin patients even right & left hepatic duct are also seen coming out of liver (Figure 3). In one case accessory bile duct was also seen coming out of right hepatic duct which was stitched with vicryl and any biliary leakage was checked in infrared as milky blue bile will be seen coming out of ductular system. In all cases any biliary leakage was seen in infrared light with water filled calot's triangle.

We had encountered 3 cases of incidental carcinoma gall bladder with stones. Out of 3 cases 2 cases were inoperable and operation terminated after taking biopsy. CBD was not visible in these 2 cases. In one case carcinoma diagnosed after biopsy and bile ducts were well visualized in this case.

Fig. 1: Window Seen in Infrared, Shows long cystic duct

Fig. 2: Infrared view after spillage of dye

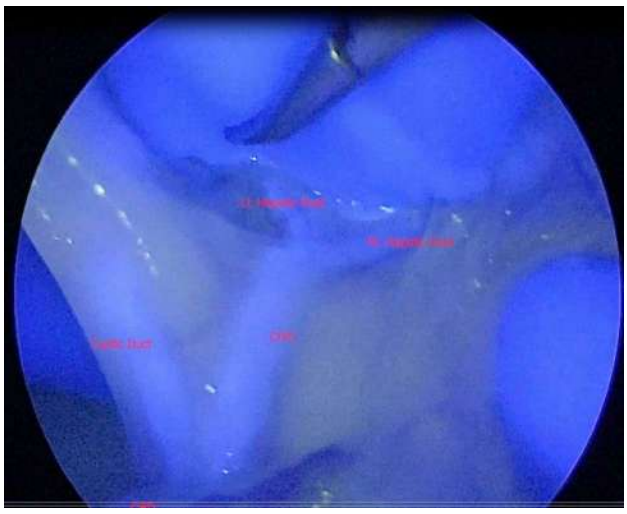

Fig. 3: Right and Left hepatic ducts well visualized

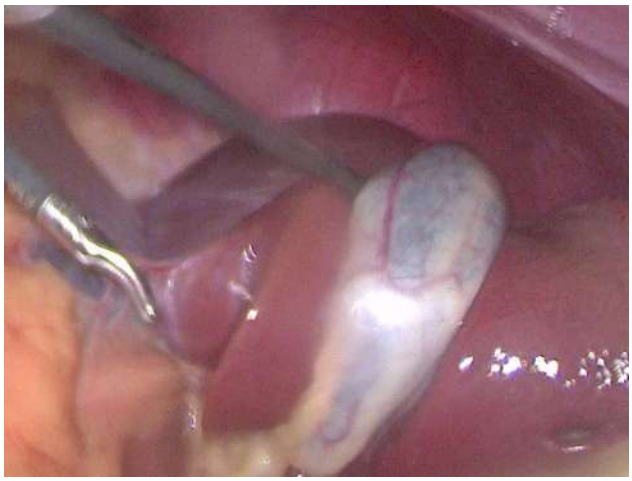

Fig. 4: A Case of Situs Invertus

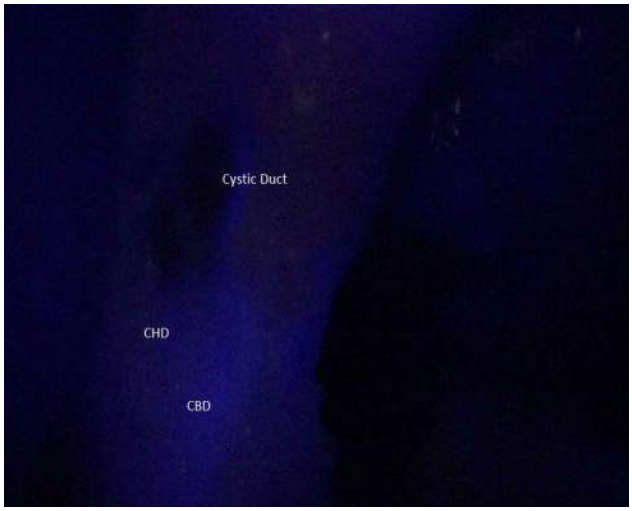

Fig. 5: SitusInvertus Case as seen in ICG Infrared

We encountered 6 cases of cirrhosis and one case of thalassaemia in our series. Dye is well visualized in all cases. In one case of situs invertus infrared technology also come into play (Figure 4 and 5).

When dye is given per operatively to assess the least time of appearance of dye, It was 7-8 minutes which is similar with study done by Prof Luigi Boni [1]. In one case of female with acute cholecystitis, it was 30 minutes. Dye takes less time to appear in female bile system than males. It is due to more plasma disappearance rate (PDR).

Discussion

No bile duct injures occurred since the use of ICG system from May 2015. Cystic duct, CBD & CHD are safe guarded against any mechanical and electrical injuries. Bile ducts are visible from beginning before dissection starts. Any mechanical or electrical injuries are prevented in infrared view. We recall our previous few bile duct injuries which can be safely prevented if we could have ICG Infrared system earlier.

As we said that we had no bile duct injuries since the use of ICG, the problem which we faced in some difficult chronic gall bladder with thick adhesions from surrounding structures. In all these cases bile ducts are not visible. In all these cases meticulous dissection played the role. In 3 cases after careful dissection, bile ducts visible deep seated in calot's triangle. Negative visualization is also help that if the tissue is not florescent in infrared then it is assumed that it is tissue other then bile duct. In 1 case of cholecysto-duodenal fistula also no duct was visible. In all together 15 cases out of 2000 cases bile ducts are not visible at all making it more than 99% sensitive.

Conclusion

To conclude, ICG system plays an important role in identifying the biliary ductal system clearly which in turn avoids injury to the ductal system in difficult cases of cholecystectomy.

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