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HEURISTICS

LAPAROSCOPIC BILE DUCT INJURY: UNDERSTANDING THE PSYCHOLOGY AND HEURISTICS OF THE ERROR

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Bile duct injury is an important unsolved problem of laparoscopic cholecystectomy, occurring with unacceptable frequency even in the hands of experienced surgeons. This suggests that a systemic predisposition to the injury is intrinsic to cholecystectomy and indicates that an analysis of the psychology and heuristics of surgical decision-making in relation to duct identification may be a guide to prevention. Review of published reports on laparoscopic bile duct injury from 1997 to 2007 was carried out. An analysis was also carried out of the circumstances of the injuries in 49 patients who had transection of an extrahepatic bile duct and who were referred for reconstruction or were assessed in a medicolegal context. Special emphasis was placed on identifying the possible psychological aspects of duct misidentification. Review of published work showed an emphasis on the technical aspects of correct identification of the cystic duct, with few papers addressing the heuristics and psychology of surgical decision-making during cholecystectomy. Duct misidentification was the cause of injury in 42 out of the 49 reviewed patients (86%). The injury was not recognized at operation in 70% and delay in recognition persisted into the postoperative period in 57%. Underestimation of risk, cue ambiguity and visual misperception ('seeing what you believe') were important factors in misidentification. Delay in recognition of the injury is a feature consistent with cognitive fixation and plan continuation, which help construct and sustain the duct misidentification during the operation and beyond. Changing the 'culture' of cholecystectomy is probably the most effective strategy for preventing laparoscopic bile duct injury, especially if combined with new technical approaches and an understanding of the heuristics and psychology of the duct misidentification error. Training of surgeons for laparoscopic cholecystectomy should emphasize the need to be alert for cues that the incorrect duct is being dissected or that a bile duct injury might have occurred. Surgeons may also be trained to accept the need for plan modification, to seek cues that refute a given hypothesis and to apply 'stopping rules' for modifying or converting the operation.

Key words: bile duct, cholecystectomy, intraoperative complication, laparoscopic.

Abbreviations: CBD, common bile duct; MBDI, major bile duct injury.

INTRODUCTION

Injury to the extrahepatic bile ducts remains the most significant operative complication of cholecystectomy and is an important unsolved surgical problem, feared because it is followed by substantial morbidity, occasional death, large additional health-care costs and frequent litigation.[1,2]

It is difficult to compare published reports of the frequency of bile duct injury because of a lack of agreement on classification of such injuries and the variable clinical criteria for inclusion of, for example, cases associated with bile leakage alone. However, after the initial high levels recorded with the introduction of laparoscopic cholecystectomy the reported frequency of bile duct injury now appears to have stabilized at 0.1–0.5%, a still unacceptably high rate, despite many publications suggesting methods of preventing the injury.[1–5] Extrapolated data from the most accurate available figures (from a statewide West Australian inpatient registry) indicate that there are approximately 150 bile duct injuries every year in Australia.[3]

Laparoscopic bile duct injury is no respecter of the seniority or experience of the surgeon.[1,6–8] The persistence of this dreadful complication, even in the hands of experienced surgeons, suggests that there are underlying systemic predispositions to the injury that merit deeper investigation. Advances in the understanding of cognitive psychology and human factors in technical errors provide useful insights into this problem.

METHODS

This review is based on an examination of the published work from 1997 to 2007 retrieved in a Medline and EMBASE search on 'Cholecystectomy/and Bile Duct Injury/and Laparoscopic Surgery', together with a review of 49 cases of laparoscopic injury referred for surgical management or analysed in a medicolegal context. The focus of the review was on patients in whom there was a major bile duct injury (MBDI) involving transection or complete occlusion of a major extrahepatic bile duct. An attempt

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was made, based on the reported circumstances of the injury, to identify psychological factors important in duct misidentification.

RESULTS

Review of published work indicated that most papers emphasized the technical aspects of correct identification of the cystic duct; few addressed the heuristics or psychology of visual perception and surgical decision-making during cholecystectomy.

In the present series, MBDI arose from duct misidentification in 42 out of 49 cases (86%). This predominance of duct misidentification is consistent with other reported series of MBDI[1,7,9] and, according to the classification suggested by Strasberg *et al.* usually results in an injury of type B, C and, most commonly, type E (Fig. 1).[2]

Another significant feature of most reports of MBDI, from the cognitive psychological viewpoint, is the occurrence of significant delay in recognition of the injury, this being defined as the surgeon having completed the operation without being aware that an injury had occurred. There was delayed recognition in 35 patients (70%) in the present series; similar delays are reported in other clinical studies of MBDI and in cases subject to medicolegal claims.[10,11] In some patients in the present series recognition of the injury was delayed for days, weeks or even months in spite of significant postoperative pointers to MBDI, such as biliary drainage, jaundice and fever.

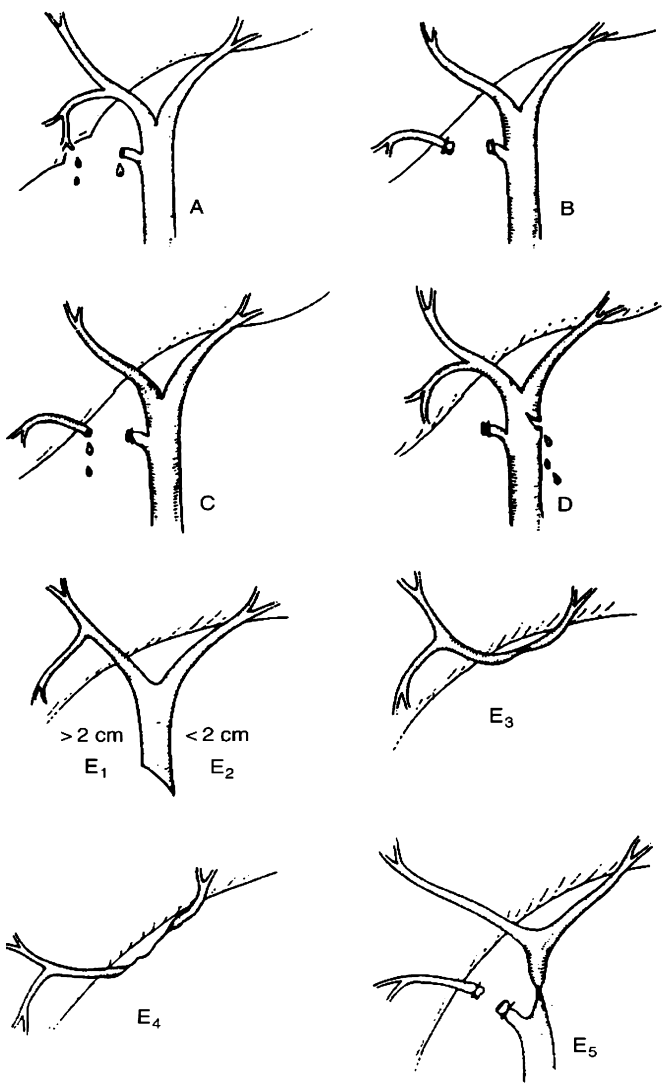

Fig. 1. Strasberg classification of laparoscopic bile duct injuries.[2]

PSYCHOLOGY AND HEURISTICS OF DUCT MISIDENTIFICATION

Much of the published work on iatrogenic bile duct injury emphasizes the need for clear identification of bile duct anatomy before dividing, clipping or cauterizing any structure. But no surgeon would divide a structure without having identified it and no surgeon would transect the common bile duct (CBD) during cholecystectomy knowing it was the common duct. The psychology in duct misidentification lies in a surgeon being persuaded sufficiently, if not believing completely, that the structure being transected is the correct one, the cystic duct. Underestimation of risk and cue ambiguity are critical contributory factors to the construction of this belief, even when in hindsight it turns out to have been false.[12]

Underestimation of risk

In the case of experienced surgeons it is possible that a chronic preoperative underestimation of the risk of laparoscopic bile duct injury may contribute to the error. An underestimation of risk in complex procedures may occur on the basis of past success in avoiding the error; this is particularly likely in MBDI because of the infrequent exposure of individual surgeons to the error.[13] Strasberg *et al.* calculated (on a basis of a rather high rate of injury of 0.4%) that a general surgeon would, on average, incur a MBDI at most once every 5 years.[2] Experienced surgeons may have a false sense of 'this can't happen to me', unaware that past success is no guarantee of future safety.[14]

Duct misidentification and cue ambiguity

Constructing a mental image that convinces the surgeon that the CBD or the right hepatic duct is the cystic duct amounts to the central error in most MBDI in the present series. The possible psychological and heuristic sources of misidentification were examined by Way *et al.*, who pointed out that intraoperative decisions in cholecystectomy have to be made from ambiguous cues forming a pattern of 'signals' (duct borders) and 'noise' (connective tissue, adhesions and blood).[1] These authors concluded that an important factor in misidentification was the absence of haptic perception in the laparoscopic technique. Haptic perception describes the perceptual information gained by active touch, as in manually examining an object such as the gall bladder. They suggested that absence of haptic perception is a laparoscopy-specific problem, based on their view that misidentification ductal injuries 'were relatively uncommon in the pre-laparoscopic era' when haptic perception was available to the surgeon at open cholecystectomy.

The available data do not support the assertion that misidentification was uncommon in the open cholecystectomy era; for example, in one study, which included 126 open cholecystectomy-related bile duct injuries, duct misidentification was a key element in the injury in most patients and 75% were unrecognized by the primary operating surgeon.[15] There is, in fact, no firm evidence that haptic perception is critically important in duct identification

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and it seems probable, therefore, that duct misidentification in both open and laparoscopic cholecystectomy is based on similar visual misinterpretation. The frequency and type of MBDI are similar in both operative methods.[16]

Visual perception is one form of heuristics – the process of acquiring, interpreting, selecting and organizing sensory information, especially uncertain, probabilistic information and using it as a basis for action: actions that themselves will make more information about the world available, thereby informing further action and so on.[17,18] What is done influences what is seen, which then helps constrain and determine what can be done.[19] This continual interweaving of action with perception means, for example, that retracting the gall bladder in a superior rather than a lateral direction increases the risk of misidentification because it tends to align the cystic duct with the CBD.[20] Strasberg has also pointed out the deceptive 'hidden cystic duct' situation created when there is difficulty retracting the gall bladder.[9]

Visual perception is not a replica of reality. It is a continual mental construction that informs and is informed by interaction with the world, where 'rules' or 'scripts' build expectations about what we (should) see.[21] As Reason points out, 'perceptions, memories, thoughts and actions have a tendency to err on the side of the familiar and the expected'.[22] When the subhepatic field is observed at laparoscopy, the surgeon usually matches what is seen with a learnt mental map of the 'normal' biliary tree. This matching is a rapid and largely subconscious process integrated with visual perception and may sometimes be a matter of 'seeing what you believe', rather than believing what you see (Fig. 2).[18] The familiar and the expected in this case is the 'normal' pattern of the biliary tree that may be mentally superimposed on a very different ductal reality. A duct that appears to merge with the infundibulum of the gall bladder may be accepted as the cystic duct when in reality it is the CBD or the right hepatic duct (Fig. 3).

Misinterpretation may lead to subsequent attribution of the MBDI by the operating surgeon as being due to 'abnormal biliary anatomy'. Although it is true that variations in the anatomy of the extrahepatic biliary tree are so common as to negate the concept of a 'normal' ductal pattern, in several cases in the present series the 'abnormal' anatomy was created by inflammatory adherence of the bile duct to the gall bladder infundibulum or by surgical traction, resulting in 'tenting' of the CBD. In two cases in the present series this tented appearance was interpreted by the operating surgeons as representing a 'double cystic duct', a further example of action influencing perception.

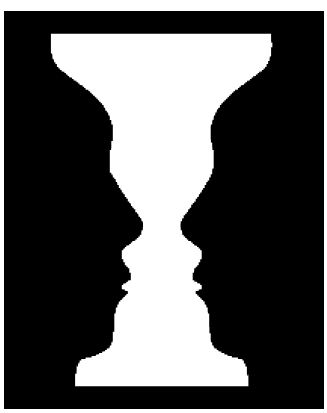

Fig. 2. Visual perception of this picture can be switched at will to represent an urn, or two persons in conversation – an example of 'seeing what you believe'.

Cognitive fixation and plan continuation

This nature of perception and action does not only help *construct* a surgeon's belief that the correct structure has been found and is being operated on. It can also *sustain* that belief during and after the procedure, even as the dissection unfolds new information, despite cues that, in hindsight, point to the true nature of the situation.[23] The usual consequence of identifying an important bile duct incorrectly as the cystic duct is that it is clipped and divided. Taking action, says Weick, simplifies the problem, but it also implies a commitment, which in turn can produce blind spots.[19] Once surgeons have committed themselves to a particular course of action they will build an explanation that justifies that action and that also guides further action. This explanation tends to persist and gets transformed into an assumption ('I am working on the correct structure') that is taken for granted during the rest of the procedure and beyond. Subsequent steps in removal of the gall bladder, for example, typically lead to an encounter with the proximal hepatic end of the divided duct (usually the common hepatic duct or the right hepatic duct), which is then divided a second time, resulting in resection of a substantial length of duct. This second cutting of the duct may not be recognized, even in the presence of unexpected intraoperative biliary leakage.

When ambiguous cues in the initial situation (and actions on it) have biased the surgeon in some direction, this elevates certain cues at the expense of others.[24] For instance, the initial interpretation typically persists throughout the dissection and division of a mistakenly identified duct, even when extra lymphatic and vascular structures show up in close proximity, when there is non-opacification of proximal ducts on cholangiography, or when the duct cannot be fully encompassed by a 9-mm clip (which to an objective observer would seem to indicate the duct was abnormally large for a supposed cystic duct).

Such 'plan continuation' often persists postoperatively. In most MBDI patients there is delay in recognition of the injury in the postoperative period; this was noted in 28 of 49 patients (57%) in the present series. Plan continuation may be remarkably strong and persistent, for example, causing the surgeon repeatedly to reassure juniors anxious about the patient's progress, even in the face of postoperative cues such as jaundice, biliary leakage or signs of biliary peritonitis that may seem in retrospect obvious indicators of duct injury (Fig. 4).

Often, none of those emergent cues is strong enough to push a surgeon off the interpretation subscribed to, or the path taken, as none of them fits the assumption that has been the basis for all action and perception up to that point. Psychology sometimes refers to this as cognitive fixation (*this and nothing else*).[25] Fixation is one possible side-effect of a mental balancing act: should a surgeon maintain stability of interpretation and course of action in the face of changing, contradictory or ambiguous cues? Or should he or she shift course of action with each newly incoming cue? Neither is desirable in most clinical situations, but ending up at one extreme (fixated on one interpretation) or the other (vacillating among multiple possible interpretations) is sometimes part of doing expert work in complex, dynamic situations.[25] One way out is the recruitment of additional, outside expertise that has not been part of the initial formulation of the problem. But when a surgeon believes that he or she has operated on the correct structure, then there is no trigger for seeking a second opinion.

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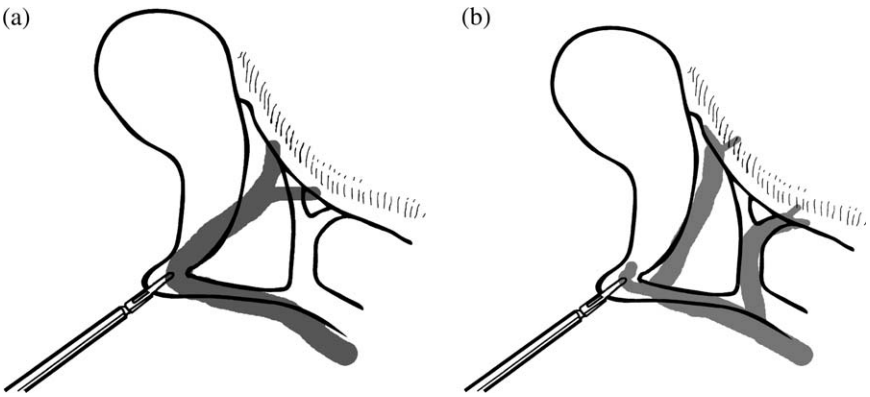

Fig. 3. A mental map of the 'normal' biliary tree may be superimposed by the surgeon on a different ductal reality (shadowed) when the common bile duct (CBD) is tented excessively by traction or is adherent and posterior to the infundibulum of the gall bladder (a). The distal CBD appears to run downwards from the gall bladder, mimicking the cystic duct. In (b) an anatomical variation (shadowed) may lead to the right hepatic duct being perceived as the cystic duct.

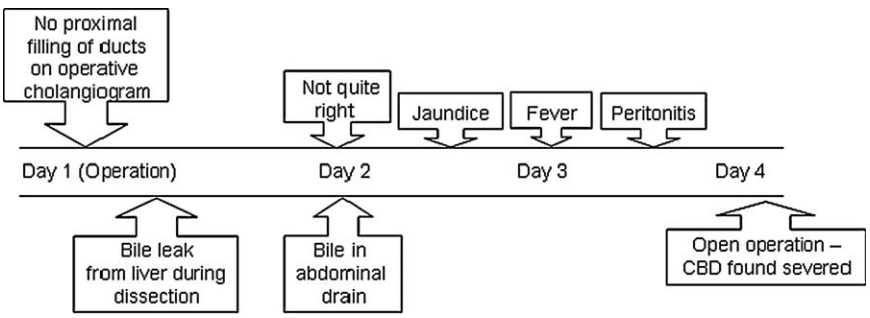

Fig. 4. Typical timeline of unrecognized cues to the presence of an injury in several cases of delayed diagnosis of laparoscopic major bile duct injury in the present series. CBD, common bile duct.

Preventive strategies

Analysis of the cognitive psychology and heuristics of major bile duct injuries in laparoscopic cholecystectomy provides a platform for developing preventive strategies.

Perhaps the most important strategy preoperatively is to encourage a deliberate sense of heightened awareness of the risk. One method is for the surgeon to repeat as a mantra while scrubbing for a cholecystectomy: 'this could be the one'; [26] another is to visualize the axiom 'think safety'.[9]

Several useful intraoperative heuristics were suggested by Way *et al.*[1] who also made technical suggestions, such as retraction of the infundibulum of the gall bladder laterally to open out the triangle of Calot (Table 1). An alternative technique is to retract the infundibulum medially to expose the posterior aspect of the triangle and to evaluate its relationship to Rouviere's sulcus, a landmark that indicates the plane of the CBD (Fig. 5).[26]

A further technical strategy is for the surgeon to develop what Strasberg *et al*. described as the 'critical view of safety' in which

Table 1. Rules of thumb (heuristics) to help prevent bile duct injuries (after Way *et al.*[1] with permission)

Technique
Use high-quality imaging equipment
Before starting the dissection, use the triangle of Calot for orientation; find the cystic duct, starting at the triangle
Pull the gall bladder infundibulum laterally to open the triangle of Calot
Clear the medial wall of the gall bladder infundibulum
Make sure the cystic duct can be traced uninterrupted into the base of the gall bladder.
Open any subtle tissue plane between the gall bladder and presumed cystic duct; the real cystic duct may be hidden in there
Factors that suggest one may be dissecting the common duct instead of the cystic duct:
The duct is not fully encompassed by a standard 9-mm clip
Any duct that can be traced without interruption to course behind the duodenum is probably the CBD
The presence of another unexpected ductal structure
A large artery behind the duct – the right hepatic artery runs posterior to the CBD
Extra lymphatic and vascular structures found in the dissection
The proximal hepatic ducts fail to opacify on operative cholangiograms
Obtain operative cholangiograms liberally
Whenever the anatomy is confusing
When inflammation and adhesions result in a difficult dissection
Whenever a biliary anomaly is suspected; assume that what appears to be anomalous anatomy is really normal and confusing until proved otherwise by cholangiograms
Convert to an open procedure when inflammation or bleeding obscures the anatomy

CBD, common bile duct.

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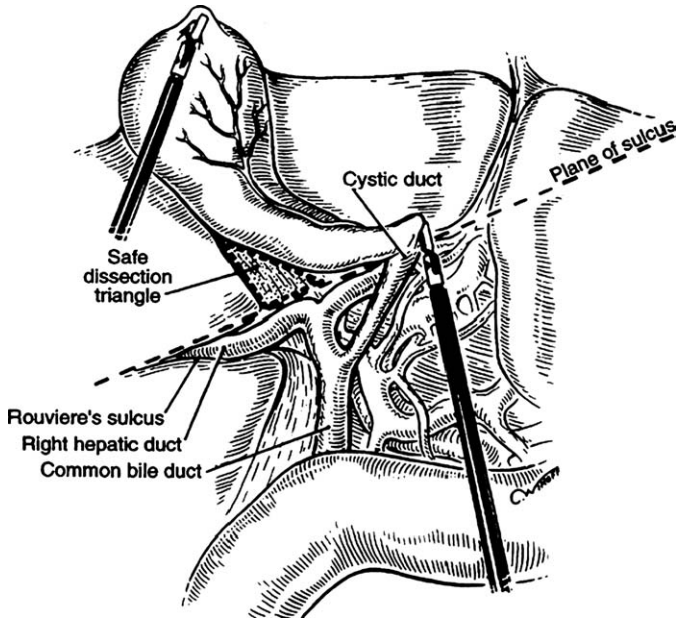

Fig. 5. Rouviere's sulcus, a cleft in the liver recognizable in >90% of patients, runs to the right of the hilum, marks the plane of the common bile duct (CBD) and is shown by retracting the gall bladder infundibulum medially. Dissection in laparoscopic cholecystectomy may be commenced safely in the triangle ventral to the plane of the sulcus.[26]

no structure is clipped or divided until the gall bladder is sufficiently free from the liver to allow visualization of just two structures entering it – the cystic artery and the cystic duct.[2]

Strasberg has also stressed the need to change the 'culture' of cholecystectomy and suggests the promulgation of 'stopping rules' as used in aviation and some other industries.[9] These might provide guidelines in difficult cases for converting to an open procedure or for modifying the operation (settling for cholecystostomy or partial cholecystectomy) before a zone of danger is entered.

The role of operative cholangiography in preventing MBDI is controversial. Although operative cholangiography probably does not reduce the frequency of MBDI, its use increases the chance of intraoperative recognition that a duct has been misidentified, possibly lessening the extent of the injury or reducing the severity of the consequences of delayed recognition.[1,2] These beneficial effects are predicated on correct interpretation of the cholangiogram and especially on recognition of the significance of non-filling of proximal ducts. Most authors suggest a selective but liberal use of cholangiography if difficulties arise in the dissection or identification of biliary anatomy.[1]

CONCLUSIONS

Laparoscopic bile duct injury continues to be an important unsolved problem of biliary surgery, regardless of the experience or seniority of the surgeon. Changing the 'culture' of cholecystectomy is probably the most effective strategy for preventing MBDI. Enhancing the individual surgeon's estimation of the risk is important. Traditional reliance on 'precise dissection and good visualization of biliary structures' to prevent MBDI is insufficient and must be supplemented by new technical approaches and an understanding of the heuristics and psychology of the duct misidentification error.[27]

Delay in recognition of MBDI is usual and contributes to poor outcomes. Long-term outcomes are superior if the injury is recognized promptly and treated definitively at an early stage. Training of surgeons for laparoscopic cholecystectomy should emphasize the need to be alert for cues that the incorrect duct is being dissected or that a bile duct injury may have occurred. Surgeons might also be trained to accept the need for plan modification, to seek cues that refute a given hypothesis and to apply 'stopping rules' for modifying or converting the operation.

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