The "Hidden Cystic Duct" Syndrome and the Infundibular Technique of Laparoscopic Cholecystectomy—the Danger of the False Infundibulum

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Background: The "classical" biliary injury usually involves misidentification of the common bile duct as the cystic duct. The purpose of this study was to determine if the method of cholecystectomy, specifically the "infundibular technique," might be a contributing factor in this injury.

Study Design: Twenty-one operative notes of patients who were referred with injury to the common bile duct were examined. Notes were classified as to informativeness. Patient and operative variables potentially related to injury were searched for.

Results: Inflammation was the main patient variable associated with injury. The main operative variable was that in most of the injuries the cystic duct was isolated and divided as the first step in the procedure. Often the operative note contained a statement indicating that the surgeon believed that the "cystic" duct (actually the common bile duct) was emanating from the infundibulum of the gallbladder and that this was the anatomic rationale for identification of the cystic duct. In no case was the triangle of Calot completely dissected before injury.

Conclusions: The cystic duct may be hidden in some patients having laparoscopic cholecystectomy, especially in the presence of inflammation. This may lead to the deceptive appearance of a false infundibulum that misleads the surgeon into identifying the common duct as the cystic duct. Biliary injury is more likely when cystic duct identification is made by relying solely on the appearance of the junction of the cystic duct with the infundibulum of the gallbladder, and this technique should be abandoned. (J Am Coll Surg 2000;191:661–667. © 2000 by the American College of Surgeons)

Biliary injury during laparoscopic cholecystectomy continues to be an important cause of morbidity. Injury rates are probably decreasing, but have not yet attained the levels that were once present in the era of open cholecystectomy.[1-3] The "classical" biliary injury occurs when the common bile duct is injured as a consequence of the mistaken belief that it is the cystic duct, ie, it is misidentified.[4] The degree of severity of the injury ranges from simple obstruction to excision of large parts of the extrahepatic biliary tree and, at worst, results in the need for a very high biliary reconstruction[5-7] or even liver resection or transplantation.

The problem of misidentification of the common bile duct as the cystic duct during laparoscopic cholecystectomy is well recognized.[1-3,8,9] A number of contributing factors have been recognized, such as direction of traction of the gallbladder[10-11] and adhesive bands.[12] Most surgeons are aware of these pitfalls. Yet despite this and all that has been written about misidentification, injuries to the common bile duct are still occurring with disturbing frequency.[3] In discussing the mechanism of injury with surgeons who have referred patients for reconstruction, we have been struck by the fact that highly competent, experienced, and informed surgeons have been convinced that they were dissecting the cystic duct when, in fact, they have been isolating a segment of the common bile duct. This has caused us to hypothesize that there might be a flaw in some techniques by which laparoscopic cholecystectomy is performed—a flaw associated with a visual deception.

There are two well-described methods for ductal identification in laparoscopic cholecystectomy.
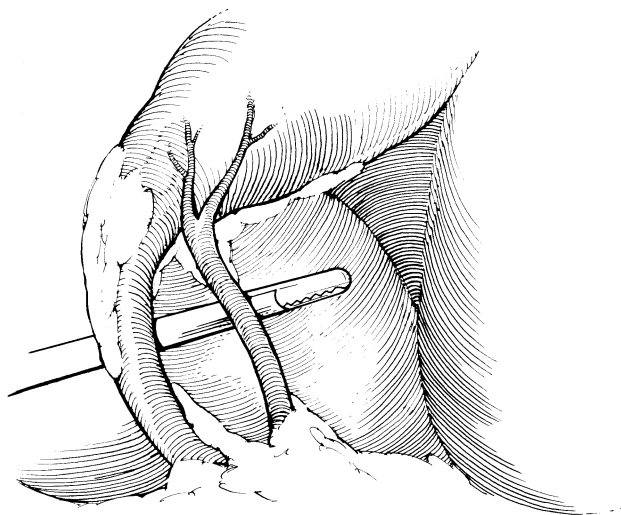
Figure 1. The "critical view of safety." The triangle of Calot is dissected free of all tissue except for cystic duct and artery, and the base of the liver bed is exposed. When this view is achieved, the two structures entering the gallbladder can only be the cystic duct and artery. It is not necessary to see the common bile duct. (Modified from: Strasberg SM, Hertl M, Soper NJ. An analysis of the problem of biliary injury during laparoscopic cholecystectomy. J Am Coll Surg 1995;180:101–125, with permission.)

One is the "critical view of safety" technique, which we described in 1995.[9] This method requires complete dissection of the triangle of Calot and separation of the base of the gallbladder from the liver bed. The anatomic rationale for identification of the cystic structures results from the fact that there are two, and only two, structures entering the gallbladder, which is otherwise still attached only by the upper part of the liver bed[9,13] (Fig. 1). The second and older method has been referred to as the "infundibular" or "infundibular-cystic" technique. In this method the cystic duct is isolated by dissection on the front and the back of the triangle of Calot and once isolated it is traced on to the gallbladder. Conclusive identification, ie, the anatomic rationale for identification, occurs as a result of seeing the characteristic flare, as the cystic duct widens to become the gallbladder infundibulum. Often this is referred to as seeing a funnel shape. The infundibular method is the one usually found in texts describing the technique of laparoscopic cholecystectomy.

The purpose of this study was to look for contributing factors to the "classical" injury. Particularly, we wished to determine whether the method of cholecystectomy was a factor in the injury. Operative notes of procedures in which such an injury

occurred were examined. The results support the conclusion that the infundibular technique is an unreliable method of ductal identification, especially when local conditions conspire to hide the true cystic duct.

METHODS

Forty-seven patients were referred to us for repair of major biliary injuries in the past 7 years. Twenty patients had injury to aberrant ducts or sustained an injury at open cholecystectomy and were not of interest in this analysis. Twenty-seven patients had undergone laparoscopic cholecystectomy and were found to have a classical injury. The operative note was available in 21 of these patients (78%). It could not be obtained in the other six patients who had a classical injury.

Operative records were examined for operative and patient variables that might have contributed to the injury. Patient variables included presence or absence of acute cholecystitis, severe chronic inflammation, wall thickening, tenseness or distension of the gallbladder, stone impaction in the infundibulum, adhesions, abnormal anatomy, and obesity. Operative variables were method of cholecystectomy, particularly whether the triangle of Calot was cleared before clipping cystic structures ("critical view" method), or whether the cystic duct was isolated and divided before complete dissection of the triangle of Calot. We sought to ascertain the anatomic rationale for concluding that the structure identified as the cystic duct was, in fact, the cystic duct—whether it was traced onto the gallbladder or followed to the common bile duct or whether operative cholangiography was used for this purpose. Excessive bleeding obscuring the field was another operative factor that was searched for.

RESULTS

Patient demographics and injury type

There were 18 women and 3 men, average age 37 years (range 16 to 78 years). The injuries occurred from 1990 to 1999; 11 of the 21 injuries occurred recently, in the years 1997–1999. The injury types were E1, three patients; E2, four patients; E3, three patients; E4, eight patients; and E5, three patients (Fig. 2). Although E5 injuries involve damage to an aberrant duct, misidentification of the common

bile duct as the cystic duct also occurs during this injury (Fig. 2), so this injury type is included in the analysis. The injury was discovered intraoperatively in 8 of the 21 patients. In the remainder the diagnosis was made in the postoperative period ranging from 2 days to 3 weeks after operation. Of these 13 patients, 7 presented with sepsis including cholangitis, 5 presented with jaundice as the main symptom, and 1 with a bile fistula.

Operative notes

There was great variability in the length and detail of the operative notes. But the subject matter of all operative notes was uniform up to the point in the dissection at which the "cystic duct" was clipped and divided. All describe, in varying degrees of detail, the preparation of the patient, creation of the pneumoperitoneum, insertion of trocars, retraction of the gallbladder, and isolation of the cystic duct (and sometimes artery).

We divided the operative notes into two categories—"informative" and "uninformative," based on whether they contained patient or operative risk factors for biliary injury and whether the surgeon provided the anatomic rationale by which he identified the cystic duct conclusively—in other words, what precautions were taken to avoid injury from misidentification. Uninformative operative notes provide almost no account of patient variables. In regard to operative factors, the description of the part of the operation in which the "cystic" duct was identified and divided in these notes may be paraphrased simply as: "The cystic duct was isolated and divided." No statement is made that indicates the anatomic rationale for concluding that the cystic duct had been isolated. There were six notes of this type and they were all much shorter than the informative notes. The median number of text lines was 16 (range 13 to 18) to the point of "cystic" duct division.

Fifteen operative notes were classified as informative. These notes always described conditions causing operative difficulty such as inflammation, and, with one exception, provided the anatomic rationale for identification of the cystic duct. Thirteen of these notes were 20 to 37 text lines in length (median 27) from the beginning of the note up to the point of "cystic" duct division. The other two notes were 54 and 70 text lines in length up to the
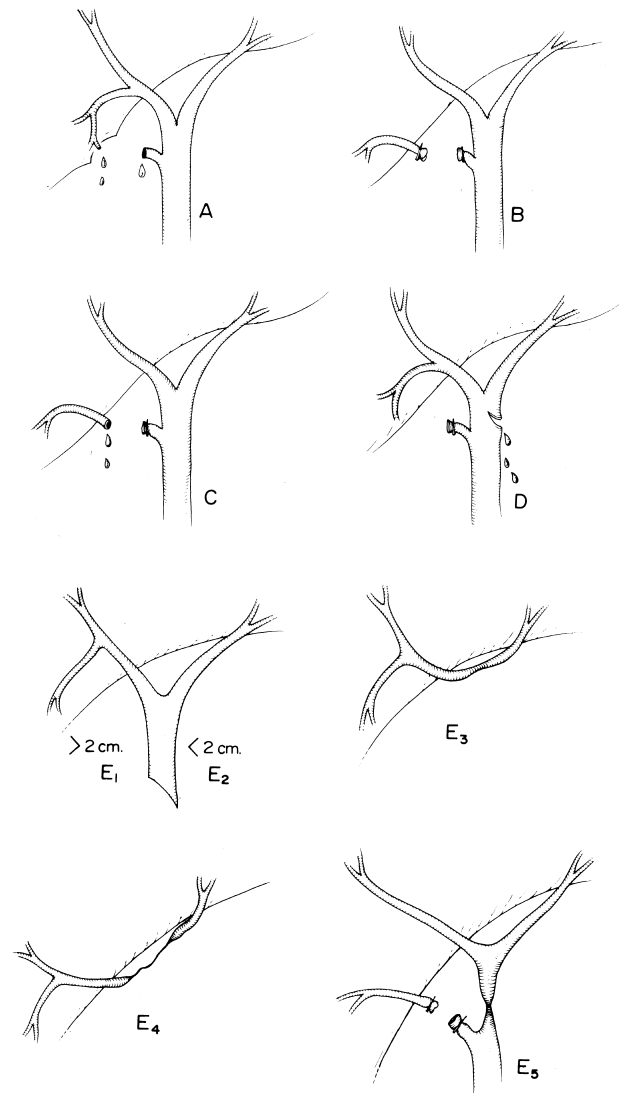
Figure 2. Classification of laparoscopic injuries to the biliary tract. Injury types A to E are illustrated. Type E injuries are subdivided according to the Bismuth classification. Type A injuries are cystic duct leaks or leaks from small ducts in the liver bed. Type B and C injuries almost always involve aberrant right hepatic ducts. Type D injuries are lateral injuries to major bile ducts. The notations >2 cm and <2 cm in Type E1 and Type E2 indicate the length of common hepatic duct remaining. (From: Strasberg SM, Hertl M, Soper NJ. An analysis of the problem of biliary injury during laparoscopic cholecystectomy. J Am Coll Surg 1995;180:101–125, with permission.)

point of "cystic" duct division and went into great detail regarding preparation, draping, and position of personnel. Very few notes gave information regarding instrumentation, eg, type of laparoscope, type of cautery, or actual instruments used to perform the dissection.

Inflammation	Acute Inflammation	Severe Chronic Infl.	Thick GB Wall	Gallbladder Distension	Impacted Stone	Extensive Adhesions	Intrahepatic Gallbladder
●	●	○	●	○	○	●	○
●	●	○	●	●	○	○	○
●	●	○	●	○	●	○	○
●	●	○	●	●	●	○	○
●	●	○	●	●	●	○	●
●	●	○	●	●	●	○	○
●	●	○	○	●	●	○	○
●	●	○	●	○	○	○	○
●	●	●	●	○	○	●	○
●	○	●	○	○	○	○	○
●	○	●	○	○	○	●	○
●	○	○	○	○	○	●	●
○	○	○	○	○	○	●	○
○	○	○	○	○	○	●	○
○	○	○	○	○	○	●	○
○	○	○	○	○	○	●	○
○	○	○	○	○	○	○	○
○	○	○	○	○	○	○	○
○	○	○	○	○	○	○	●
○	○	○	○	●	○	○	○
○	○	○	○	○	○	○	○

Figure 3. Patient variables in 21 "classical" bile duct injuries. Filled circle indicates that variable was present.

Patient variables (Fig. 3). Acute cholecystitis was present in 9 of 21 patients. In all cases it was noted to add to operative difficulty. In three other patients nonacute inflammation, ie, chronic inflammation and scarring, were noted and contributed to the difficulty of the procedure. So, inflammation was present and considered by the surgeon to add to operative difficulty in 12 of 21 patients.

Increased thickness of the gallbladder and distension or tenseness of the gallbladder were described in nine and six patients, respectively. All but one description of distension and all but one of increase in wall thickness were found in operative notes of patients with acute cholecystitis. The presence of one or both of these factors was often accompanied by a remark that these factors led to problems in grasping or retracting the gallbladder, ie, operative difficulty. In three patients, all with acute cholecystitis, there was a notation that a large stone was impacted in the infundibulum, and that as a result, grasping and retraction of the gallbladder was made more difficult.

Three operative notes indicated that there was trouble grasping the gallbladder because it was intrahepatic, and seven operative notes remarked on considerable numbers of adhesions that required dissection. Unlike the preceding three factors (distension, thickened wall, and impacted stone) intra-hepatic site and adhesions were not specifically associated with inflammation (Fig. 3).

Only one note described bleeding as a problem in visualizing the cystic duct and this was not in a case of inflammation. Two operative notes describe "aberrant" arterial anatomy with a "cystic" artery running in front of the "cystic" duct, which, in actuality, was probably a right hepatic artery that ran in front of the common hepatic duct, as it does in approximately 15% of patients.

Operative variables. By far the most important finding in these notes was that in 17 of 21 procedures (81%) the "cystic" duct was isolated and divided as the first step in the dissection of the triangle of Calot, and that in none of the 21 patients was the triangle of Calot cleared of fat and fibrous tissue and the base of the gallbladder taken off the liver bed as described in the "critical view" technique. There is no mention of the cystic artery in these 17 operative notes until after division of the "cystic" duct. In the four other patients the surgeons note that the cystic artery was visible or was also isolated before division. Nine of 12 patients in whom inflammation was present and 8 of 9 patients in whom inflammation was not present were approached by the method in which the first step in the dissection of the triangle of Calot is the dissection, isolation, and division of the "cystic" duct.

Table 1. Precise Paraphrases of Operative Statements Embodying the Anatomic Rationale for Identifying the Cystic Duct in Eight Patients with Injury to Common Bile Duct

Patient No.	Statement
1	Dissection was carried proximally along the cystic duct. It appeared to flare into the gallbladder. Dissection was carried onto the gallbladder for 1.5 cm, proving that the duct was the cystic duct.
2	The cystic duct was isolated and there appeared to be a continuous cystic duct coming from the gallbladder.
3	The cystic duct was identified and seen to enter the gallbladder in the appropriate direction.
4	The cystic duct was isolated and appeared to arise at the gallbladder.
5	A tubular structure arising from the inferior aspect of the gallbladder was isolated. The infundibulum was mobilized and the structure was seen to enter the gallbladder.
6	The neck of the gallbladder was identified and the cystic duct dissected and isolated.
7	A structure was identified which came right off the infundibulum. This appeared to be the cystic duct and was dissected circumferentially.
8	Dissection is commenced as close to the gallbladder as possible. The cystic duct is dissected out and a clip is placed next to the gallbladder.

Closer scrutiny was made of the 17 procedures in which isolation and division of the "cystic" duct was the first step in dissection of the triangle of Calot in an attempt to determine how the common bile duct was misidentified as the cystic duct. In 7 of 17 patients there was no statement regarding the anatomic rationale for identification. In two cases the surgeon states that the cystic duct was followed to the junction of the common bile duct. But in the other eight patients the surgeon derived identification from a relationship between what was perceived as the cystic duct and the neck of the gallbladder. The relevant operative statements are given in a precisely paraphrased form in Table 1. Note that in each instance the surgeon believed that he saw the cystic duct emanating from the gallbladder. Stated otherwise, in 8 of 10 operative notes in which the rationale for avoidance of misidentification was available, that rationale was that the surgeon believed he had seen the cystic duct join the gallbladder, ie, the infundibular technique of identification failed in its purpose.

Cholangiography was performed in four patients. Dye did not enter upper bile ducts in any these studies. Only the common bile duct and duodenum were seen. In three patients this finding was not considered abnormal and the "cystic" duct was divided. In fact, the common bile duct was divided and the injury was carried to a much higher level in the subsequent dissection leading to an E3 and two E4 injuries. In two of these patients the common hepatic duct was found to be applied to the gallbladder when the specimen was removed. In

the fourth patient, it was recognized that there might be a problem when dye did not fill the upper ducts. The surgeon thought this might be from leakage of dye around the cholangiography catheter. He attempted to improve closure around the catheter but this led to tearing of the common bile duct and an E1 injury.

DISCUSSION

The infundibular technique of laparoscopic cholecystectomy and biliary injury

The major finding of this study is that infundibular technique for identification of the cystic duct appears to be unreliable. Nearly 80% of the injuries examined occurred using a technique in which the cystic duct was identified and divided before dissection of the rest of the triangle of Calot. In 8 of 10 patients in whom the anatomic rationale for identification of ducts was provided, it was that the surgeon thought he saw the cystic duct join the infundibulum of the gallbladder, ie, the anatomic rationale inherent in the infundibular technique was used.

Figure 4 illustrates the flaw that appears to be present in the infundibular technique. On the left is what the surgeons believed they have achieved up to the point in the dissection when they are ready to occlude and divide the cystic duct. It appears that the cystic duct can be seen emanating from the gallbladder. This is based on the fact that the sides of the tubular structure, which has been isolated and followed toward the gallbladder, are diverging, ap-
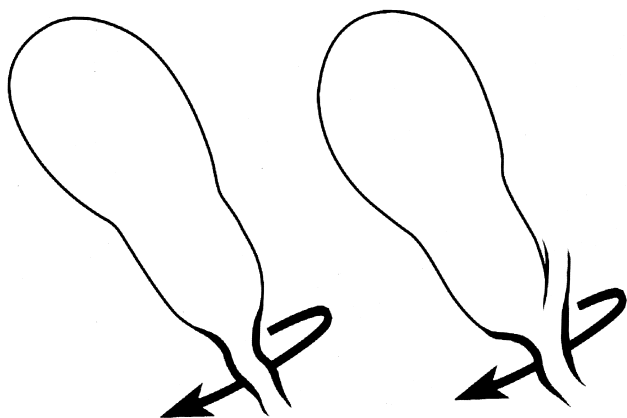
Figure 4. The deception of the hidden cystic duct and the infundibular technique of laparoscopic cholecystectomy. Left: Appearance to surgeon when a duct appearing to be the cystic duct is dissected first. Note that the duct appears to flare (heavy black line), giving the appearance that the cystic duct has been followed onto the infundibulum. Right: True anatomic situation in the case of some classical injuries. The "flare" (heavy black line) is from the separation of cystic and common hepatic ducts or the side of the common hepatic duct and the side of the gallbladder. Note that such a deception is impossible if the dissection is carried to the "critical view" (Fig. 1) before dividing any structure.

parently to become the infundibulum of the gallbladder. The appearance is deceptively similar to what has been seen on many earlier occasions as the true cystic duct enlarged to become the infundibulum of the gallbladder. The picture on the right shows the true anatomic situation in the case of misidentification; the common bile duct has been isolated and the divergence of its walls as it comes near the gallbladder is from its division into the cystic duct and common hepatic duct. These two structures naturally diverge at this point. As a result of the apparent widening or "flaring" of the presumed cystic duct, the surgeon concludes that he is on the infundibulum of gallbladder, but it is a false infundibulum. This appearance seems also to be caused sometimes by the inflamed gallbladder overlying the cystic duct, common hepatic duct, or both, so that the sides of the common bile duct do actually appear to expand onto the gallbladder. The surgeon thinks he is operating on the cystic duct at the edge of the gallbladder but actually the dissection is taking place on the common bile duct at the edge of an inflammatory mass in which the cystic duct is hidden. An infundibulum seems to have been identified but again it is a false infundibulum.

Hiding the cystic duct—the role of inflammation and other factors

The operative notes indicate that the problem of a false infundibulum is much more likely under certain conditions. The most important is extensive inflammation, especially acute inflammation. The chief reason for this has already been noted; inflammation of the gallbladder tends to hide the cystic duct. Inability to effectively grasp and retract the gallbladder and thereby straighten and expose the cystic duct also appears to be important. Under these circumstances it seems more likely that dissection will begin below the inflammation around the left and right sides of the common bile duct rather than on the front and back of the triangle of Calot. Other factors that obscure the position of the cystic duct include large impacted stones; effacement of the cystic duct so that it is short or absent, as in Mirizzi's syndrome; and adhesions that tether the common duct to the gallbladder, hiding the cystic duct.[12]

The role of intraoperative cholangiography

Routine cystic duct cholangiography reduces the incidence of biliary injury, as demonstrated in a recent report from Australia by Fletcher and colleagues.[14] Cholangiography was performed in only 4 of 21 patients in this series and was misinterpreted in 3 patients. Intraoperative cholangiography, if correctly interpreted, undoubtedly would have prevented, or at least reduced, the extent of injury in many patients in this series. Obviously, a cholangiogram is of little use if it is not correctly interpreted.

Cholangiography has problems other than that images may be misinterpreted and injury still occur. Mistaken cannulation of the common bile duct for the purpose of anatomic identification may not be innocuous. It will, at the least, require conversion and repair over a T-tube and, at worst, require biliary reconstruction.

This was shown in one patient in this series in whom attempts at cholangiography, through what was mistakenly believed to be the cystic duct, led to an E1 injury of the common bile duct. Also "cystic duct" cholangiography does not reliably identify the presence of aberrant right hepatic ducts[9] and may not prevent these types of injuries (Type B and C, Fig. 2), which are much more common when performing laparoscopic cholecystectomy than

open cholecystectomy.[15] In the era of open cholecystectomy, routine cholangiography was not advocated as the standard technique of anatomic identification, but rather as a technique of bile duct stone identification. The standard technique of conclusive identification was by dissection using a method analogous to the "critical view" technique.

Teaching laparoscopic cholecystectomy

Although this series is small, there is a very high degree of consistency in the findings. They strongly suggest that the infundibular technique for identification of the cystic duct is unreliable, especially under conditions of acute inflammation. Given the serious consequences of a biliary injury and the fact that other, more secure methods for identification exist, it would be logical to abandon the infundibular technique. This technique is advocated in many texts on laparoscopic surgery, and is in common use. Its proponents would argue that the technique is good, the failure in the cases in this series being from misapplication of the method, and not from a flaw in the rationale. But it is apparent that well-trained, skilled, and experienced surgeons are involved in these injuries and there is now a clear understanding of how surgeons can be misled by a hidden cystic duct and the appearance of false infundibulum. Our findings suggest that it is unsafe and should be abandoned as a standard method of laparoscopic cholecystectomy.

None of the injuries occurred in operations in which the cystic duct was fully dissected out as recommended in the "critical view" technique. Cholangiography demonstrated an abnormality in all patients in whom it was used, and injury would have been avoided or reduced if interpretation had been appropriate. In the "critical" view technique, isolation of the cystic duct is not the object of the initial part of the dissection as in the infundibular technique. The object is to clear the triangle of Calot entirely of fat and fibrous tissue so that two, and only two, structures are seen to enter the gallbladder, and the base of the gallbladder is taken off the liver bed. It is highly unlikely that visual deception will occur if the dissection is carried to this point. If the critical view is not attainable the dissection is stopped. Then the operation is converted

or a cholangiogram is performed for the purpose of anatomic identification. The use of cholangiography selectively under these circumstances mimics its use for anatomic identification in open cholecystectomy. Our study suggests that either one adopt this approach or that routine cholangiography, as suggested by others,[14] be used once the presumed cystic duct is isolated. Our bias is that anatomic identification be done by dissection rather than cholangiography, for reasons stated above. The infundibular technique, meaning a technique in which one relies on the shape of the infudibulocystic junction as the sole method of anatomic identification should be abandoned.

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