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Special Article

Biliary imaging: magnetic resonance cholangiography versus endoscopic retrograde cholangiography*

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THE TECHNIQUES used for imaging of the biliary tree show continuing and rapid development. Ultrasonography has been improved considerably and is an easily accessible and cheap initial step in diagnosing biliary diseases; image processing may further increase its usefulness. Computerized tomography, and more recently magnetic resonance imaging, have tremendously improved noninvasive imaging of the biliary tree (1–7).

Since its introduction in the 1970s, endoscopic retrograde cholangiography (ERC) has been the gold standard for imaging of the bile ducts. The number of purely diagnostic ERC's, however, has been declining in recent years, at least in larger centres. The possibility of combining a diagnostic approach with a therapeutic procedure in a single session is the major advantage of ERC. But even when used in a purely diagnostic approach, ERC may occasionally cause fatal complications. With the advent of magnetic resonance cholangiography (MRC) in the early 1990s (8), the future role of diagnostic endoscopic retrograde cholangiography has been questioned.

MRC images are accomplished by acquiring heavily T2-weighted MR sequences. To elucidate the technique in brief, the heavily T2-weighted sequences result in a high signal intensity of stationary or slowly moving fluids like bile, but in a low signal intensity of solid organs or of rapidly moving fluids. Hence, the portal vein and the hepatic artery will show signal void (9,10). Fast spin-echo sequences reduce the time required for image acquisition, and enhance the visualization of the biliary tree. Breath-hold techniques during data acquisition have been added to enhance imaging (9,11). With maximum intensity projection (MIP), images closely resembling those obtained at ERC are generated by computerized image processing (12). The rapid acquisition with relaxation enhancement (RARE) technique has shortened the data acquisition time and the breath-holding time (13,14). The ultimate half-Fourier acquisition single-shot turbo-spin echo (HASTE) technique further improved the quality of the images (11,15–24).

Several points will be raised in this review comparing MRC with ERC. The items to be discussed include diagnostic accuracy, discomfort, complications, operator dependence, availability, and costs.

A considerable number of papers have been published comparing MRC with ERC. In few reports, however, are detailed data shown on the sensitivity and specificity of MRC evaluated in a prospective, blinded fashion against ERC as the gold standard (16,25–30). Overall, MRC shows excellent sensitivity of about 90%, with little difference between the reports (Table 1). Patients with bile duct stenoses of various origin, suspected stones, or other biliary diseases were included in these trials. The specificity of MRC shows a larger variability between the reports, ranging from 78 to 100% (Table 1). Extrahepatic stenoses, dilated bile ducts, and larger stones were detected by MRC with a very high accuracy. Circumscript stenoses of the intrahepatic biliary tree without prestenotic dilatation still represent a diagnostic challenge for MRC. MRC can, however, detect dilated bile ducts which are not opacified by ERC due to complete stenosis. In the detection of stones in the bile ducts, comparable figures for sensitivity, but better values for specificity were published (Table 2). Thus, bile duct stones can be excluded quite reliably by MRC. This is of particular interest in acute pancreatitis of unknown origin, where ERC can cause additional harm. According to our own experience, however, MRC may occasionally fail to detect tiny stones. In several studies, either a retro-

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* Dedicated to Prof. Dr. Gustav Paumgartner on the occasion of his 65th birthday.

TABLE 1

Sensitivity and specificity of magnetic resonance cholangiography (MRC) as compared to endoscopic retrograde cholangiography (ERC) used as the gold standard in patients with biliary obstruction. Only papers reporting prospective, blinded evaluations were included

	Reference	Patients	Sensitivity	Specificity
Chan et al.	25	n=45	95%	85%
Guibaud et al.	26	n=79	91%	100%
Hintze et al.	27	n=55	89%	78%
Holzknecht et al.	16	n=61	91%	80%
Soto et al.	29	n=46	95%	94%

TABLE 2

Sensitivity and specificity of magnetic resonance cholangiography (MRC) as compared to endoscopic retrograde cholangiography (ERC) used as the gold standard in patients with suspected stones in the bile ducts. Only papers reporting prospective, blinded evaluations were included

	Reference	Patients	Sensitivity	Specificity
Guibaud et al.	26	n=32	81%	98%
Hintze et al.	27	n=6	100%	100%
Holzknecht et al.	16	n=24	92%	96%
Lomanto et al.	30	n=62	92%	100%

spective or an unblinded design was used, no clear data on the sensitivity or the specificity are shown, or MRC was compared not only with ERC but also with operative cholangiography, percutaneous cholangiography, CT scans, ultrasonography, or clinical follow-up (5,20–22,31–34). In general, these data confirm those obtained in the studies referred to above (Tables 1 and 2). The interobserver variability in the interpretation of MRC images is very low (16,35).

One of the advantages of diagnostic ERC is the possibility of simultaneously obtaining bile samples. Tumour markers such as CEA, CA 19–9, fibronectin, K-ras mutations or p53 thus can be analysed in bile (36–42). Furthermore, cytology specimens obtained by intraductal brushing and tissue obtained by intraductal biopsy can be sampled for further examination. Brush cytology obtained at ERC, however, has sensitivities of only 20–60%. The specificity reaches 60–70% with repeated brushing. For intraductal biopsy, comparable figures are reported. If repeated brushings and biopsies are applied to the same stricture, the diagnostic yield may be somewhat better. Neither brush cytology nor intraductal biopsy carries a substantial risk if blood coagulation is normal (43–54). While brush cytology devices are small enough to be inserted into the bile duct without sphincterotomy, a biopsy forceps frequently cannot be inserted via an intact papilla.

The discomfort and pain reported during ERC are caused by insertion of the endoscope, inflation of gas, manipulations at the papilla, increasing the pressure within the biliary tree by injection of contrast medium, and lying in an uncomfortable position. Therefore, ERC is usually performed after intravenous sedation and/or analgesia. The discomfort associated with MRC is minimal and the acceptance of MR examinations by patients is excellent (55). Except in patients with claustrophobia or some paediatric patients, sedative medication is not required for MRC.

When certain limitations are respected, such as metallic material in the region of interest, the complications associated with MRC can be regarded as minimal or virtually absent (5,16,20–35,56–58). There are few data on the complications of merely diagnostic ERC, while most reports also include the complications observed in therapeutic procedures. Furthermore, no data are available on the complications of diagnostic ERC when injection into the pancreatic duct has been strictly avoided. This can be achieved in about 75% of ERC examinations (59). Adverse effects of ERC include pancreatitis, cholangitis, and cardiopulmonary complications caused by the drugs used for sedation, analgesia, or spasmolysis. Pancreatitis was observed after 0.4% to 1.3% of ERC procedures (60,61). Apparently, ERC-induced pancreatitis can be a more severe disease than pancreatitis due to other causes (62). Cholangitis or sepsis can be expected to occur in about 0.1% to 0.8% of the examinations. Drug reactions were observed in about 0.6% of the examinations; respiratory arrest, however, was observed in only 0.1% (60). Fatal complications were reported in 0% to 0.2% of the ERC examinations (60,61). The number of adverse reactions attributable to contrast medium is very low, probably because the contrast medium injected into the bile ducts is delayed before entering the systemic circulation (63).

While early reports showed visualization of the bile ducts in only 70% of ERC procedures (61), recent data revealed that imaging of the biliary tree is obtained in 95% to nearly 100% of the attempts (59,60). Failures of ERC occur more frequently if the endoscopist has performed less than 200 ERC's (64). Thus, ERC is operator dependent. In contrast, the bile ducts are sufficiently visualized in nearly all MRC studies (8,13,14,16,19). The number of examinations a radiologist needs to perform to become experienced in MRC is not known, but it may well be in the same range as for the endoscopist. In severe bile duct obstruction, ERC may fail to opacify bile ducts proximal to the obstruction. In addition, opacification of pre-stenotic bile ducts may cause cholangitis in patients with severe strictures. Particularly in patients with advanced pri-

mary sclerosing cholangitis or with Caroli's disease, liver function may deteriorate following ERC (65,66). MRC can be regarded a useful alternative in such patients when the limitations of the method for visualization of small intrahepatic bile ducts are taken into account (67). When the papilla cannot be reached by ERC due to anatomic abnormalities or to previous operations, MRC can serve as an advantageous substitute (20,57,68,69).

In children and in pregnancy, it is especially worthwhile to minimise the radiation hazard. Only under certain circumstances, might it be possible to perform ERC without fluoroscopy (70). Complete avoidance of radiation can be achieved by MRC. Hence, MRC is of particular advantage in children with biliary atresia or other congenital disorders of the bile ducts, or after liver transplantation (71,72).

Endoscopic ultrasonography could also serve as an alternative avoiding radiation. It is a diagnostic method which is still developing. It has been shown to be equivalent to ERC in detecting bile duct stones, or distal bile duct cancers (73–77). Endoscopic ultrasonography also avoids the severe complications of ERC (e.g. pancreatitis, cholangitis). However, endoscopic ultrasonography requires a skilled endoscopist, a costly and fragile device, the discomfort of a rather large instrument, and a relatively long duration of examination. The role of intraductal endosonography using miniprobes or of cholangioscopy using miniaturized devices inserted via the working channel of conventional duodenoscopes still has to be established (78–81). A combination of endoscopy, endoscopic ultrasonography, and magnetic resonance imaging is being evaluated (82).

While ERC is widely available at present, MRC is restricted to centres equipped with up-to-date technology. It can be expected that the rapid spread of new technology will lead to widespread availability of MRC in the near future. Up-to-date technology is of pivotal importance to achieve the diagnostic accuracy reported in recent MRC trials. No comparison is available on the cost-efficacy of diagnostic ERC versus MRC. However, with regard to the cost of the devices, the technical aspects, the duration of the procedure, and the need for skilled personnel, most probably there is no clear cost-advantage of either method.

In conclusion, the major advantages of endoscopic retrograde cholangiography are its high diagnostic yield, the possibility of obtaining ductal biopsies and bile specimens, and of performing therapeutic interventions within the same session. Hence, whenever the likelihood of a therapeutic procedure is high, ERC is the method of choice. The major drawbacks of diagnostic ERC are the associated discomfort and the complications. MRC is without relevant adverse effects and has a diagnostic accuracy close to that of ERC, with the exception of microlithiasis and minute stenoses which have not yet been studied adequately. Thus, whenever a purely diagnostic approach to the bile ducts is anticipated, MRC will be the method of choice for visualization of the biliary tree in the near future.

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