Is rotational cholangiogram a feasible investigation for obstructive jaundice? A comparison study with conventional percutaneous transhepatic cholangiogram.

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Purpose

Despite the increasing popularity of CT cholangiography and MR cholangiography as imaging tools in the investigation of biliary obstruction, PTC is still recognised as the gold standard for visualising the biliary system, providing images of the highest resolution\textsuperscript{1,2}. Although PTC is invasive, this procedure is often necessary to not only delineate the anatomy of the biliary system but also to drain patients with obstructive jaundice.

PTC is more often now performed fluroscopically either by cine or imaging hold technique, and assisted by digital cholangiography (DC). To clearly delineate or define the site of obstruction, acquisition in multiple projections and planes is often required. This would not only incur additional radiation dose but frequently does not provide optimal angle to overcome duct overlap. Although rotational cine fluroscopy can be performed, the plane of rotation is limited and the signal-to-noise ratio and resolution are less favourable compared to DC.

Recent advances in the technology of rotational angiography (RA) have allowed the acquisition of images that can be reconstructed to produce 3D images. This technique, with the primary intention of demonstrating the cerebral circulation, rendered images that vastly improve spatial orientation and help to define the anatomy more accurately, particularly in the case of overlapping tortuous anatomy\textsuperscript{3,4}. The success of RA in cerebral circulation imaging has been applied to other body systems including the lacrimal, biliary tract and urinary tract\textsuperscript{1,5-8}. Two early studies on rotational cine cholangiography (with and without 3D reconstruction) had found the technique to be useful in the evaluation of bile duct carcinoma and as a pre-surgical work-up tool for patients with obstructive jaundice\textsuperscript{1,7}. Since then, there has been no other published work on rotational cholangiography (RC) or three dimensional rotational cholangiography (3D-RC).

The aim of this study is to further determine the potential role and to look at the feasibility of performing RC in the investigation of obstructive jaundice by comparing the cine and 3D technique against conventional cholangiography (CC) in terms of image quality and radiation dose incurred.

Methods and Materials

This is a cross-sectional study consisting of 13 patients (8 female, 5 male; age range: 21-77 years, mean age: 60.5 years) with obstructive jaundice who were referred for Percutaneous Transhepatic Biliary Drainage (PTBD) from January 2008 to June 2009.
The reason for PTBD was either for palliative care of malignancy or relief of biliary obstruction following a failed endoscopic stenting. The study was approved by the Medical Ethics Committee and informed consent was obtained from each patient prior to examination. The diagnosis and cause of obstructive jaundice were obtained from earlier examinations including ERCP, ultrasonography, CT or MRI.

All patients were imaged with a Siemens angiography unit (Axiom-Artis VB30E, Germany), single plane AXIOM Artis dFa C-Arm Angiography System (Siemens, Germany), flat panel detector system with 48cm diagonal entrance plane producing an image of 1920 x 2480 matrix with 154 µm pixel size.

**Procedure:**

- puncture of the biliary system performed as per routine practice for PTC.
- diluted 30-60 ml of contrast media (Ultravist 300 mgI/ml) injected through a catheter or drainage tube.
- following adequate opacification, CC performed via fluoscopic cine or imaging hold technique and single-shot DA. Compulsory projections in postero-anterior, bilateral 20° oblique, 20° oblique cranio and 20° oblique caudal performed to ensure standardisation.
- rotational cholangiography performed next by centering the C-arm at the hepatic region and rotating the C-arm at an angle of 200° and angulation step of 0.5° per frame. The total rotation time was 8 seconds, producing 419 projections. To ensure similar or adequate opacification of the biliary tree as in CC, 10 to 20 ml of diluted contrast was infused prior to, or during, the rotational acquisition when necessary. Patients were asked to hold their breath during acquisition.

All study images and raw data were then transferred automatically to a workstation (syngo Workplace). Using the software AXIOM Artis VB30 with InSpace 3D high contrast software, the RC source images were then reconstructed into 3D images using the volume rendering technique (VRT). The rotational cholangiogram source images were reviewed and analysed in both cine and 3D mode at a later time by two interventional radiologists, each with eight years of experience. They were blinded to the findings of the conventional cholangiogram at the time of review. The results were reviewed and the final decision with any discrepancy was reached by consensus between the two reviewers.

The parameters analysed were as follows: order of branches, delineation of stenosis or obstruction, and overlapping of branches. Based on these parameters the image quality of each examination was graded as 'excellent', 'acceptable' and 'poor'. Table 1 summarises the grading criteria of the image quality.
The radiation total dose area product (DAP) and calculated entrance surface dose (ESD) of each acquisition were measured using the built-in electronic dose measuring chamber available in the C-arm system.

Statistical analysis of image quality was performed using SPSS version 15.0 and rank sum Wilcoxon test. Difference in radiation dose was determined by paired sample t-test with \( p \)-value of <0.01 considered as statistically significant.

Images for this section:

Table 1: Grading criteria of image quality.

<table>
<thead>
<tr>
<th>Image Quality</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>1. Demonstration of up to third-order branches</td>
</tr>
<tr>
<td></td>
<td>2. Point of stenosis or obstruction is clearly delineated or outlined.</td>
</tr>
<tr>
<td></td>
<td>3. No overlapping of branches</td>
</tr>
<tr>
<td>Acceptable</td>
<td>1. Demonstration up to second-order branches</td>
</tr>
<tr>
<td></td>
<td>2. Point of stenosis or obstruction is identified but not well delineated or outlined.</td>
</tr>
<tr>
<td></td>
<td>3. Minimal overlapping of branches</td>
</tr>
<tr>
<td>Poor or not of diagnostic</td>
<td>1. Demonstration of up to first-order branches only</td>
</tr>
<tr>
<td>quality</td>
<td>2. Point of stenosis or obstruction is not identified</td>
</tr>
<tr>
<td></td>
<td>3. Marked overlapping of branches</td>
</tr>
</tbody>
</table>
Results

The underlying diseases in these patients were: carcinoma of pancreas (3 patients), carcinoma of stomach (3 patients), non-malignant post-surgical anastomotic stricture (3 patients), cholangiocarcinoma (2 patients) and calculus (2 patients). A total of 18 examinations were performed with 1 patient having 3 examinations and 3 patients having 2 examinations. The reasons for repeat examination were change of drainage catheter due to blockage and catheter slippage.

No reaction related to contrast material was recorded in any of the subjects. None of the patients recorded signs or symptoms of sepsis following the procedure. Approximately 2-3 minutes of user time was required for the creation of the 3D images. All patients referred for PTBD had successful drainage catheter insertion into the biliary system immediately following the examination. Only 1 patient had a metallic stent insertion, performed 2 weeks after the PTBD.

Image Quality

Cine rotational cholangiography produced 'excellent' image quality in 17 (94.4%) of the 18 examinations (figure 1) and 'acceptable' quality in 1 examination due to inadequate delineation of site of obstruction.

The image quality of the reconstructed 3D images was significantly affected by motion artifacts caused by breathing in 8 of the 18 examinations, to a degree that they were regarded as 'unacceptable' or 'poor' quality. However in 10 of the 3D-RC studies which were not affected by breathing artifacts, 'excellent' image quality was seen in 9 studies and 'acceptable' image quality was seen in 1 study. One examination was graded as 'acceptable' image quality because although the generated 3D images could determine the site of obstruction clearly and overcome branch overlap, they were only able to demonstrate up to the second-order branch.

As for CC, 'excellent' image quality was seen in 6 (33.3%) of the 18 studies. The remaining 12 (66.7%) studies were graded as 'acceptable' image quality because of minimal branch overlapping in 7 studies, inability to demonstrate third-order branch in 2 studies, unsatisfactory delineation of obstruction site in 2 studies, minimal branch overlapping with unsatisfactory delineation of obstruction site in 1 study.

None of the CC or cine RC study was considered of 'poor' or non-diagnostic quality. Significantly better image quality was seen in cine RC than in CC (p = 0.004) (figure 2). The only study graded as 'acceptable' image quality in cine RC, similarly generated images of 'acceptable' quality in VRT and CC.
Two examinations produced 'excellent' image quality in the VRT technique but 'acceptable' image quality in the CC technique due to inadequate delineation of obstruction site in one and branch overlap with inadequate delineation of obstruction site in the other (figure 3). However, no significant statistical relationship in image quality could be established between 3D-RC and CC.

There was no change in image quality seen between the different techniques in the repeat examinations. Table 2 summarises the results of image quality for each technique.

<table>
<thead>
<tr>
<th>Image quality</th>
<th>CC (n/%)</th>
<th>Cine RC (n/%)</th>
<th>3D (n/%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>6/33.3</td>
<td>17/94.4</td>
<td>9/50</td>
</tr>
<tr>
<td>Acceptable</td>
<td>12/66.7</td>
<td>1/0.6</td>
<td>1/5.6</td>
</tr>
<tr>
<td>Poor</td>
<td>-</td>
<td>-</td>
<td>8/44.4</td>
</tr>
</tbody>
</table>

**Table 2:** Results of image quality analysis.

CC- Conventional Cholangiography  
Cine RC- Cine Rotational Cholangiography  
3DRC- Three Dimensional Rotational Cholangiography

**Radiation dose**

The mean DAP and ESD recorded by the 18 RC studies was $4686.86 \pm 1162.04$ mGy and $175.41 \pm 51.433$ mGy respectively while the mean DAP and ESD recorded by the same number of CC studies was $1510.07 \pm 1031.74$ D-RC mGy and $88.03 \pm 52.71$ mGy respectively. The mean DAP and ESD of RC were significantly higher than those of CC, with a difference of $3176.79 \pm 864.05$ mGy ($p=0.00$) and $87.38 \pm 34.86$ mGy ($p=0.00$), respectively.
Fig. 1: Cine RC performed through a drainage tube showing an excellent display of biliary confluence stricture and clear demonstration of the biliary duct branches.

Fig. 2: CC image (A) and Cine RC image (B) of a patient with cholangiocarcinoma showing dilatation of the intrahepatic and common hepatic biliary ducts. A long segment of stenosis involving the common bile duct (arrows) is seen in the cine RC image but not demonstrated in the CC image.
Fig. 3: CC images (A and B) and 3D-RC images (C and D) of a patient with advanced stomach malignancy, showing dilated intrahepatic biliary ducts. The CC images in different projections could not clearly demonstrate the point of obstruction due to overlapping of branch at the hilar region. The manipulated 3D images, on the hand, could demonstrate obstruction at the proximal common bile duct (block arrow) and a short tight stricture at the distal left common hepatic duct just before the confluence (arrow).
Conclusion

In the diagnostic work-up of obstructive jaundice, it is imperative that the cause and level of obstruction be determined. Often non-invasive imaging tools, specifically ultrasound, CT and MRI, are able to provide this information. However, sometimes a more invasive technique, namely PTC, is required to resolve some issues not answered by earlier investigations. With the success of rotational angiography in neuroradiology, it is interesting to see if this technique could be applied in the investigation of the biliary system. However, to date there have only been 2 published studies on rotational cholangiography using angiography system\(^1\).

This study's series of 18 examinations confirm that cine RC provides better depiction of the bile duct anatomy and the obstruction site compared to CC. The biliary duct anatomy, which can be greatly distorted and complicated by an obstruction, is better understood and displayed in cine RC than by CC. In the few examinations where 3D images were able to be reconstructed, the authors found the images to be of 'excellent' or 'acceptable' quality. The robust reconstructed 3D images can be easily manipulated to allow review of difficult areas in various angles and projections.

There are, however few limitations or drawbacks to the current study. First, being a subtracted study, motion or misregistration artefact due to breathing has a direct effect on the 3D image reconstruction. This is especially evident when imaging organs close to the diaphragm. In this study's series, artifacts due to patient's breathing had greatly interfered with the reconstruction of 3D images in almost half of the studies, rendering them unacceptable for analysis. Similarly less than adequate quality caused by motion artifact was also documented by Uchida, \textit{et al.} in one of their studies\(^1\). This emphasises the importance of breath-holding during the image acquisition of RC.

A second drawback of this study is that the radiation dose imposed by RC on our patients was significantly higher than the radiation dose imposed by conventional cholangiogram by 3fold. This was not totally unexpected, because unlike in RC where examinations were primarily performed using DA, image acquisitions in CC were mainly acquired using fluoroscopy, which undoubtedly delivered much lower doses than DA. Previous studies comparing the radiation dose between rotational acquisition and conventional method have also shown similarly higher radiation dose with rotational acquisition. Luchtenberg \textit{et al.}, in their paper on 3D-rotational dacryocystography (3D-RD), reported a 1.2- to 1.7-fold increase in radiation dose measurements for 3D-RC compared with a single plane DSA dacryocystography\(^5\). Although the high radiation dose may not pose much impact or effect on elderly patients, the authors propose that future studies in RC should consider using larger angulation step per frame as a radiation dose-reducing measure.
A third limitation is the absence of clinical correlation between the examination findings and patient management. Although significant differences in image quality were found between RC and CC, this study did not demonstrate if these findings would necessarily affect the patient's management as patients recruited in this study were non-surgical candidates planned for conservative treatment.

This study demonstrates that RC is a feasible method that offers more information over conventional technique, which is the current gold standard in depicting biliary anatomy. However, due to the relatively higher radiation dose, it may not be applicable as a routine clinical imaging procedure.

References


Personal Information