Coronal 2D MR Cholangiography Overestimates the Length of the Right Hepatic Duct in Liver Transplantation Donors

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Background

The length of the right hepatic duct (RHD) influences the yield of the ductal openings when harvesting the right hepatic lobe from living donors. A short RHD may result in a higher chance of obtaining two ductal openings while a long RHD favors single ductal opening. Given that, it should be noted that the length of the RHD measured on 2D T2-weighted single-shot projection MR cholangiography (MRC) may not be accurate due to its inherent limitation of planar 2D projection acquisition. Inaccurate measurement can be either longer or shorter than the actual length, depending on the projection angle and overlap of adjacent structure (Fig 1) .

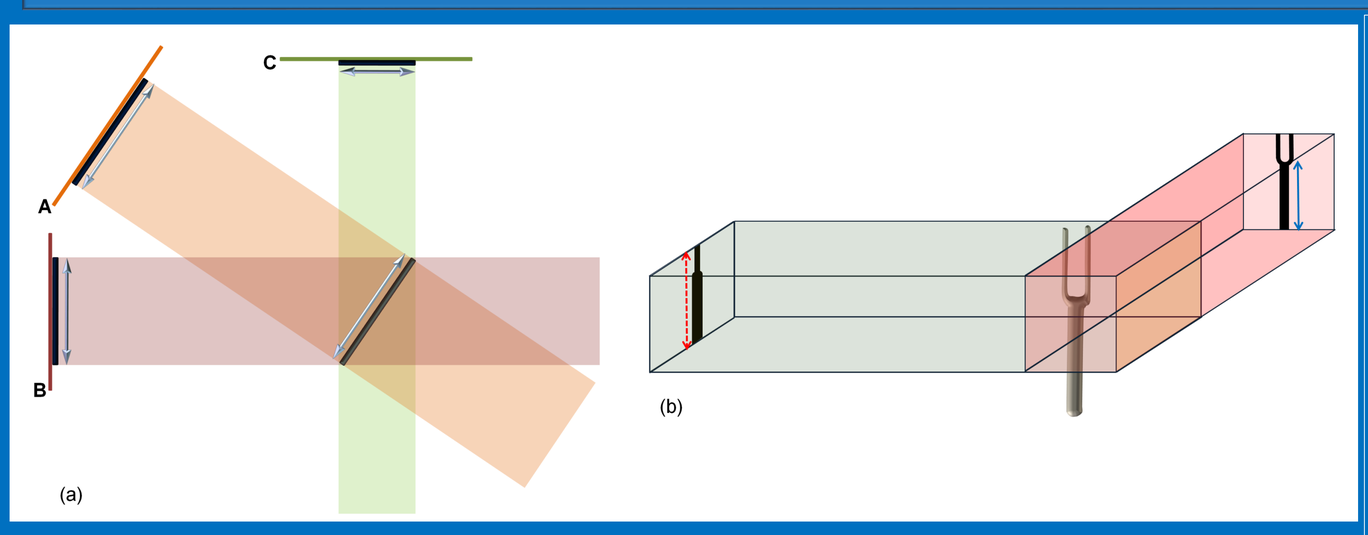


Figure 1. Diagrams demonstrating pitfalls of planar 2D projection images.
(a) Depending on the angle between the plane of target structure and that of the projection image, the length of the structure on each image can be variable. If the plane of the projection is parallel to that of the target structure, the measured length on planar image is ideally equal to the true length of the structure, as in A. If the plane of the projection is askew, the measured length on planar image is foreshortened than the exact length, as in B and C.
(b) On projection images, superimposition of separate structures can result in misrepresentation of the exact anatomy as well as the length of the target structure. On a projection plane that causes overlap of separate structures, the length of the target structure can be overestimated (dashed line versus solid line). In order to overcome the pitfalls, planar images are obtained from multiple rotatory projection planes

Purpose

To assess the accuracy of the measured length of RHD on projectional 2D MRC in coronal and axial planes, taking the length measured on reconstructed 3D MRC images as a standard reference.

Materials and Methods

A total of 67 donors underwent MRC consisted of projectional single-section rapid acquisition with relaxation enhancement (RARE) in coronal and axial orientations with 15° of rotation intervals and respiratory-triggered 3D T2-weighted sequences. The length of the RHD was measured and categorized as ultrashort (≤1 mm), short (2-14 mm), and long (>14 mm) on each image set. The length was compared using ANOVA, paired t-test, and Bland-Altman analysis. Chi-square test and Student's t-test were used to compare the frequency of overestimation and the degree of underestimation between two projection planes.

Results

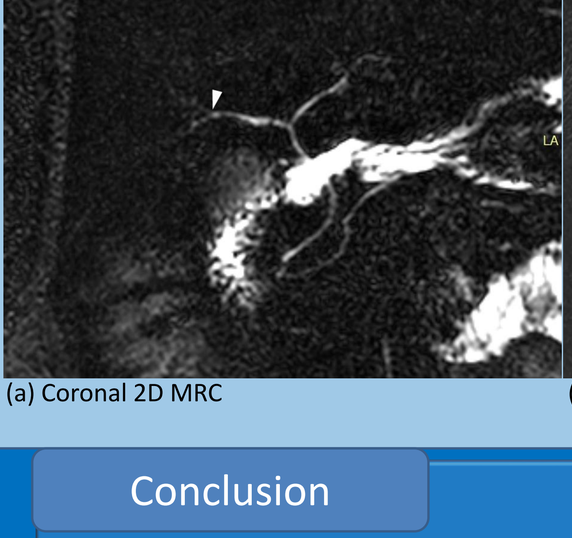
The length of the RHD was frequently overestimated on the coronal than on axial 2D MRC (61.2% vs. 9%; $p < .0001$) (Table 1). On coronal 2D MRC, four subjects (6%) with short RHD and one subject (1.5%) with ultrashort RHD were over-categorized as long RHD. On axial 2D MRC, the overestimation was mostly < 1 mm (83.3%) with neither case exceeding 3 mm nor over-categorized. There was no significant difference in the degree of underestimation between the two projection planes.

		Coronal 2D MRC	Axial 2D MRC	*P*[a]
Mean difference (%)[b]		22.1%	15.1%	
Number of overestimation		**41 (61.2%)**	**6 (9%)**	**< .0001**
Degree of overestimation	Less than 1 mm	10 (14.9%)	5 (83.3%)	
	1 to <3 mm	19 (28.4%)	1 (16.7%)	
	3 to <5 mm	8 (11.9%)	0	
	≥5 mm	4 (6%)	0	
Average length of overestimation		2.5 mm ± 2.6	0.5 mm ± 0.7	< .0001
Number of underestimation		**21 (31.3%)**	**53 (79.1%)**	**< .0001**
Degree of underestimation	Less than 1 mm	11 (16%)	13 (24.5%)	
	1 to <3 mm	6 (9%)	28 (52.8%)	
	3 to <5 mm	3 (4.5%)	7 (13.2%)	
	≥5 mm	1 (1.5%)	5 (9.4%)	
Average length of underestimation		-1.6 mm ± 1.7	-2.2 mm ± 1.8	0.18

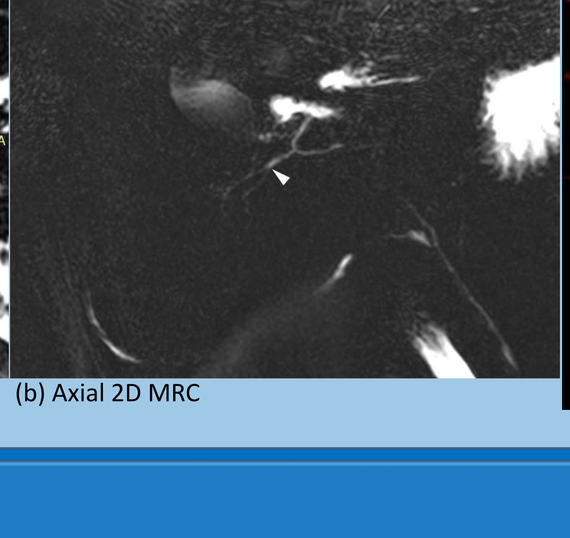
Table 1. The frequency and degree of over- and underestimation of RHD on 2D MRC compared with 3D MRC
[a]According to Chi-square test and Student's t-test
[b]Compared with 3D MR cholangiography

	3D MRC	Coronal 2D MRC	Axial 2D MRC	*P*[a]
Mean ± SD (mm)	12.3 ± 7.1	13.3 ± 7.7	10.6 ± 6.7	< 0.05
Range (mm)	1-31.1	1-32	1-29.5	

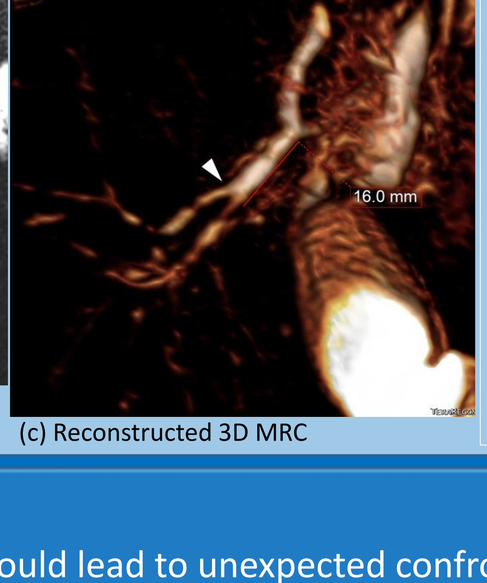
Table 2. The length of the RHD measured on MRC
[a]According to repeated-measures two-way analysis of variation



(a) Coronal 2D MRC



(b) Axial 2D MRC



(c) Reconstructed 3D MRC

Preoperative MRC of a 65-year-old female liver donor. Images were obtained that demonstrate the longest length of the RHD on (a) coronal 2D MRC, (b) axial 2D MRC, and (c) manually reconstructed 3D volume rendering image from volumetric 3D MRC. Arrowhead indicates the expected confluence of right anterior and posterior segmental branches in each image (a-c). On coronal 2D MRC, RHD was measured to be 15 mm (a). On axial 2D MRC, the length was measured to be 8 mm (b). On 3D volume rendering image, the length was 10.4 mm (c). The length was overestimated and over-categorized to be long RHD on the coronal 2D MRC, whereas it was correctly categorized to be short RHD on axial 2D MRC. Overestimation on coronal 2D MRC is most likely due to overlap of horizontal-lying right anterior and posterior segmental branches just distal to the secondary confluence.

Conclusion

Rotatory coronal 2D MRC overestimates the RHD length, which could lead to unexpected confrontation with multiple ductal openings when harvesting the graft. We suggest adding axial 2D MRC routinely to conventional coronal 2D MRC in a preoperative workup protocol.