MRI of cloacal anomalies: Can it substitute conventional imaging?

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Purpose

Persistant cloaca is considered the most complex anomaly of female anorectal and urogenital systems. It has a reported incidence of 1: 50,000 newborns [1]. Meticulous assessment of the internal organs and associated urogenital anomalies is crucial for proper surgical planning to obtain the best functional outcome [2].

Contrast studies through the perineal orifice and colostomy opening are considered the reference standard imaging modality. However, in addition to radiation exposure, it may be technically challenging to perform, and is frequently confusing to interpret [3].

Since the 1980s, MRI has been used in the assessment of patients with ARA. Despite being considered the investigation of choice for postoperative evaluation of patients presenting with fecal incontinence [4], the role of MRI in the preoperative assessment of anorectal anomalies is still uncertain with only few reports in the literature. While some authors recommend preoperative MRI only when suspecting spinal cord anomalies [5], others recommend it for all patients [6].

Our purpose was to study the ability of MRI to explore the different anatomical aberrations of persistent cloaca and whether it can substitute other preoperative imaging modalities.
Methods and Materials

A prospective study was conducted, between July 2007 and March 2011, to evaluate the role of MRI in the preoperative assessment of patients with persistent cloaca in relation to information provided by conventional imaging, endoscopic, and operative findings. The study was approved by the hospital internal review board. It included seven patients with colostomy for persistent cloaca awaiting reconstructive surgery. Their age ranged from 2 to 18 months (mean 7 months).

**MRI examination:**

- Oral chloralhydrate (50-100mg/kg) was used for sedation [7].
- MRI was performed using a 1.5-T machine.
- The study was performed in the **supine** position
- **Quadrature split top head coil** was used, and included: axial (fast spin-echo) T1 and T2 WI, coronal T2 WI and sagittal T2WI (with and without fat suppression) of the pelvic region with the coronal plane perpendicular and the axial plane parallel to the pelvic floor; sagittal T1 and T2 WI of the lumbosacral spinal canal; and coronal T2 WI of the abdomen including the spine. The slice thickness was kept as thin as possible (3 mm) with a small interslice gap (0.5 mm). Complementary MRU was performed when dilatation of the urinary tract was found.

**Image analysis:**

At first, due to paucity of data in the literature, the MRI was interpreted in conjunction with the conventional imaging, and then compared with endoscopic and operative findings. In the last 2 patients, MRI was interpreted separately and compared to conventional imaging and operative findings. The work station was a personal computer. The scans were reviewed as soft copies, using a DICOM viewer program.

- We diagnosed **high type** cloaca when the cloacal confluence was at or above the pubococygeal line (PC line), and **low type** when it was below the PC line [2].
- The cloacal anomaly was also classified according to rectal termination into: **vaginal communication**, if the rectum joins the vagina in its posterior wall; and **cloacal communication** if the rectum terminates into the common cloacal channel [1].

- Location and bulk of striated muscle complex (SMC) were assessed and graded either fair if it appeared continuous, or poor if it had interrupted appearance.

- Associated anomalies of the genitourinary tract, vertebrae, and spinal cord were identified. Low lying conus was diagnosed when the conus medullaris terminates below the level of L-2 inferior endplate[8].

- We applied novel MRI parameters for studying cloacal anomaly:

  1) **Urethral length** (distance from bladder neck to urogenital confluence) (Fig. 1 on page 5).

  2) **Relative hiatal distance** which is measured as ratio of pelvic hiatus to pubococcygeal distance (pelvic hiatus is the distance from lower end of pubis to anterior margin of levator plate; and pubococcygeal distance from lower end of pubis to lower end of sacrum) (Fig. 2 on page 5)

  3) **Vaginal volume** was measured by manual segmentation method in axial T2WI.

  The relations between these parameters were tested statistically using Pearson correlation test.

**Conventional imaging:**

included distal loopogram through the mucous fistula, followed by genitogram through the common cloacal opening.

**Operative technique:**

one patient associated with congenital heart (tricuspid atresia) died before the corrective surgery. In the rest, the surgery was preceded by endoscopic evaluation, and video recordings were available in 4 patients. Reconstruction was performed through a perineal sagittal approach in all but two patients who underwent a combined abdomino-perineal approach.
Fig. 1: Sagittal T2WI of a 12 months old patient with high type cloaca. A) The urethra is seen as thin tubular structure with hyperintense mucosa (arrow). B) The urethral length is measured as the distance from bladder neck to the urogenital confluence. (b: bladder; R: rectum; v: vagina).

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Fig. 2: Sagittal T2WI of a 12 months old patient with high type cloaca. The pelvic hiatus (H) is the distance from lower end of pubis to anterior margin of levator plate; and pubococcygeal distance (PC) is the distance from lower end of pubis to lower end of sacrum. The relative hiatal distance is calculated as ratio of pelvic hiatus (H) to pubococcygeal distance (PC). Note: the narrow hiatus seems to obstruct the vagina (v) that appears distended (estimated volume 15 ml).(b: bladder; R: rectum; v: vagina).

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Results

The level of bowel termination and confluence of uro-genital tracts were identified in mid sagittal T2WI images, and this was confirmed in axial images. Additional fat suppression sequences improved the detection of the urethra, vagina and rectal termination which were demarcated by their hyperintense mucosa (Fig. 3 on page 9).

Six patients were diagnosed as high type cloaca and one patient as low type. The type of rectal communication was defined as vaginal in two patients, and as cloacal in five. In vaginal communication type the rectum showed short distance of tapering after which it joined the vagina at its posterior wall (Fig. 4 on page 9). In cloacal communication type, the rectum showed longer tapering distance till it joins the common cloacal channel. In one patient, this long fistulous tract is seen adherent to the vaginal septum and appears as if it is embedded between the two distended vaginal cavities (Fig. 5 on page 10).

MRI findings were consistent with conventional, endoscopic and operative findings in all but one patient in which the rectum appeared in the colostogram in a lower position than it actually was (Fig. 6 on page 11). This distortion should have resulted from the pressure exerted during contrast injection through the distal colostomy (this is recommended in order to visualize the fistula) [9].

The genital system was assessed in sagittal, coronal and axial T2WI. Normal uterus was detected in two patients, and appeared as tubular structure of intermediate signal myometrium with thin central hyperintense endometrium (Fig. 3 on page 9 B). Normal vagina was noted in one patient (low cloaca) and appeared as cylindrical structure; its wall exhibited hypointense signal with central hyperintense mucosa (Fig. 3 on page 9 A). In one patient the vagina appeared capacious yet not distended, its wall was thickened exhibiting intermediate to dark signal with minimal amount of fluid is seen inside (Fig. 7 on page 12).

Mullerian anomalies were present in five patients (71%). Mullerian hypoplasia was detected in one patient. The hypoplastic mullerian ducts appeared as two small oval structures of dark signal intensity seen at the dorsal aspect of the bladder in axial T2WI (Fig. 8 on page 13). Uterine didelphys was detected in two patients, and appeared as two separate uterine bodies; both were associated with septated vagina. Septated uterus was detected in two patients and was also associated with longitudinal vaginal septum. The external fundal contour appeared convex with a hypointense longitudinal septum dividing the uterine cavity and continuous with the hypointense vaginal septum (Fig. 9 on page 14). Hydrocolpos was detected in four patients (57%).
Associated urinary tract anomalies were detected in three patients (42.8 %) included hydro-ureteronephrosis in three patients, and unilateral renal agenesis in one patient.

Vertebral anomalies were present in five patients (71 %) and included absent, hemi (Fig. 10 on page 15 ), and fused vertebrae. Low lying conus medullaris was noted in two patients and was associated with fibrolipoma of the filum terminal. Associated hydromyelia was noted in one of them (Fig. 11 on page 15).

In the mid sagittal plane, the striated muscle complex (SMC) appeared to be composed of three components (Fig. 12 on page 16) deep horizontal muscle, representing the levator plate; 2) thin vertical strip of muscle extending from the anterior margin of the levator plate backwards and caudally towards the predestined site of the anus, representing puborectalis and external sphincter; and 3) superficial horizontal muscle extending from the distal end of the external sphincter to the coccyx, representing parasagittal ano-coccygeal muscle. SMC was poorly developed in two patients with partial sacral agenesis.

The novel MR parameters (the urethral length, relative hiatal distance and vaginal volume) were calculated in all patients. The relative hiatal distance was related directly to the urethral length (p-value=0.035), and indirectly to vaginal volume (distension) (p-value=0.051). The shorter the urethra, the narrower the hiatus, and the more was the obstruction (vaginal distension).
Fig. 3: Sagittal (A), and sequential axial T2WI (B & C) of an eight months old patient with low type cloaca. A) Fat suppressed sagittal T2WI demonstrating the relatively hyperintense mucosa of the urethra, vagina, and fistulous rectal termination converging distally into the common cloacal channel (long arrow) below the pubis. B) Axial T2WI showing the uterus as rounded structure with intermediate signal myometrium and hyperintense thin central endometrium (short arrow). C) The rectum is seen tapering forward into the common cloacal channel. (b: bladder; R: rectum).

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Fig. 4: Sagittal T2WI of an 18 months old patient with high cloaca showing vaginal communication type. The rectum showed short distance of tapering after which it joined the fluid filled vagina (v) at its posterior wall (arrow). (b: bladder R: rectum).

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Fig. 5: MRI, conventional, and endoscopic findings in an 18 months old patient with persistent cloaca. A) Mid sagittal MRI showing the urinary bladder (b), distended vagina (v), and rectum (R). The three systems converge to meet in the common cloacal channel (white arrow) above the pubococcygeal line (high type cloaca); black arrows point to the long rectal fistula before joining the common cloacal channel. B) coronal MRI showing distended septated vagina (v), and the rectum (R) descending behind. Congenital hip dysplasia on the left side with joint effusion are also noted. C) axial MRI showing urinary bladder (b), septated vagina (v), and rectum (arrow) descending posteriorly behind the vaginal septum (s). Note the superior illustration of the anomaly in different planes, which was helped by the distension of the vagina by fluid (urine). D) and E) conventional contrast X-ray showing the rectum and double vagina, while the urinary bladder could not be opacified. F) cystoscopic view showing the septum (S) dividing the vagina (v), and the fistulous opening of the rectum behind the vagina in the common cloacal channel (cloacal communication).(b: bladder; R: rectum; s: septum; v: vagina)

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Fig. 6: Seven months old patient with persistent cloaca. A) High pressure distal colostogram showing the rectum (R) in a lower position (below the coccyx). B) Mid sagittal MRI of the same patient showing the actual level of the rectum (R) opposite the lower border of the 4th sacral vertebra.

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**Fig. 7:** Axial T2WI of a two months old patient with high type cloaca demonstrating capacious vagina, its wall was thickened exhibiting intermediate to dark signal (arrows) with minimal amount of fluid inside. (R: rectum, b: bladder, *: terminal end of the dilated left ureter).

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Fig. 8: Axial T2WI (A) and operative image (B) of a 12 months old patient with high type cloaca. A) Two hypoplastic mullerian ducts (black arrows) appear as two small oval structures of dark signal intensity between the bladder (b) and rectum (R). B) The operative image shows two atretic mullarian ducts (black arrows). White arrow points to the site of ligation of the rectal fistula. (ov: ovaries).

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**Fig. 9:** Coronal (A) and axial (B) T2WI of an 18 months old patient with high type cloaca showing septated uterus and vagina. A) The external fundal contour appeared convex (arrows) with a hypointense longitudinal septum dividing the uterine cavity and continuous with the hypointense vaginal septum (S). The vagina (v) appears mildly distended with fluid (urine). B) The hypointense uterine septum (arrow) is seen dividing the hyperintense endometrium lined uterine cavity.

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**Fig. 10:** Coronal T2WI showing hemivertebra of the fourth sacral vertebra (arrow).

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Fig. 11: Sagittal T2WI (A) and axial T1WI (B) of an 18 months old patient with high type cloaca showing A) Low lying conus medullaris at midbody of L3 level indicative of tethered cord, associated with hydromyelia (long arrow), dysplastic sacrum and absent coccyx. B) fibrolipoma of the filum terminal is seen (short arrow) exhibiting characteristic T1 hyperintense signal.

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Fig. 12: Sagittal T2WI demonstrating the striated muscle complex (SMC) exhibiting hypointense signal, and composed of three components: 1) deep horizontal muscle, representing the levator plate; 2) thin vertical strip of muscle extending from the anterior margin of the levator plate backwards and caudally towards the predestined site of the anus, representing puborectalis and external sphincter; and 3) superficial horizontal muscle extending from the distal end of the external sphincter to the coccyx, representing parasagittal ano-coccygeal muscle. Posterior angulation of the last piece of sacrum is noted.

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Conclusion

MRI is a valuable tool in exploring the different internal anatomical features of the cloacal anomaly. The level of bowel termination and the type of rectal communication with the common cloacal channel are depicted. Developmental state of striated muscle complex is assessed. Associated anomalies of the spine and genitourinary system are also perceived.

The pelvic hiatus is the anterior opening in the levator ani muscle that provides a path for the bowel and urogenital tracts to the exterior (perineum). In persistent cloaca, failure of normal development of the rectum and vagina through the pelvic floor results in a narrow hiatus which may reach the extent to cause obstruction to the genital tracts that is manifested by their dilatation (hydrocolpos). The higher the cloacal confluence (the shorter the urethra), the narrower was the hiatus, and the more was the obstruction.

MRI provides several advantages in the preoperative assessment of patients with persistent cloaca; and when combined with endoscopy, it can make other preoperative imaging unnecessary.
References


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