

# How Prevalent is Hydronephrosis Secondary to Acute Appendicitis: A Cross-Sectional Study

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**ABSTRACT:** **Background:** Right hydronephrosis secondary to acute appendicitis is an under-reported phenomenon with only several case reports published.

**Objectives:** To assess the incidence of this phenomenon in our database of patients diagnosed with acute appendicitis.

**Methods:** Data were collected on 1092 patients who underwent surgery due to acute appendicitis between 2003 and 2007 in our tertiary medical center. The data entailed demographic, surgical, and hospitalization parameters including ultrasound or computed tomography examinations and presence of right hydronephrosis prior to surgery.

**Results:** Out of 1092 patients, appendicitis was eventually diagnosed in 87.4% of the patients. Only 594 (54%) had preoperative imaging performed prior to surgery (ultrasound or computed tomography). Out of these 594 patients, 21 (3.5%) had a new right hydronephrosis diagnosed and all had appendicitis with 15/21 (71%) having a retrocecal appendix. Of those with retrocecal appendix, 10 were pregnant women (48%). Erythrocyturia was present in 15/21 patients (71%) and in 10/11 of patients (91%) after excluding those who were pregnant. No significant differences were seen in patients with hydronephrosis regarding age, hospitalization, and surgery time. In all patients, an ultrasound was performed 2 weeks after surgery demonstrating the disappearance of hydronephrosis. Median follow-up time was 41.7 months (range 14.8–118.4 months).

**Conclusions:** Our study shows that 3.5% of our cohort had right hydronephrosis secondary to acute appendicitis. Although this presentation is very rare, physicians should be aware of this phenomenon and the risk for delayed diagnosis and treatment of acute appendicitis.

IMAJ 2018; 20: 141–144

**KEY WORDS:** hydronephrosis, acute appendicitis, ultrasound, computed tomography (CT), surgery

Acute appendicitis constitutes the most common clinical indication for urgent abdominal surgery, with an estimated lifetime incidence of 8.6% in men and 6.7% in women [1]. It is caused by an obstruction of the appendiceal lumen by a fecal

stone, hyperplasia of the lower epidermal lymphatic tissue, parasites, or tumor, which triggers a vicious cycle of pathological changes [2]. Common symptoms include upper mid-abdominal or periumbilical pain, which then migrates to the right lower quadrant, frequently accompanied by poor appetite, nausea, and vomiting. However, only 50–60% of patients present with the classical symptoms rendering atypical clinical presentation quite common [3]. Urinary tract involvement in patients diagnosed with acute appendicitis represents an example of the latter, including microscopic hematuria and right lower abdominal or flank pain resulting from unilateral ureteral obstruction related to periappendiceal inflammation or an abscess [4,5].

Hydronephrosis and hydroureter without concomitant impairment of renal function have been associated with ruptured appendicitis [6], likely as a result of altered ureteral peristalsis. Other rare urologic manifestations of acute appendicitis include urinary retention [7] and bilateral ureteral obstruction [8].

To date, to the best of our knowledge, there are only a few published case reports describing patients presenting with hydronephrosis secondary to acute appendicitis. The clinical course and outcome of hydronephrosis secondary to acute appendicitis remain unclear. We sought to characterize this uncommon clinical phenomenon, which may delay the diagnosis of acute appendicitis.

## PATIENTS AND METHODS

We received institutional review board approval. Using a prospective database available at that time [2], we retrieved data on 1092 consecutive patients who underwent surgery in our medical center due to acute appendicitis between 2003 and 2007. We specifically looked at preoperative imaging findings when available (computed tomography and ultrasound) for the presence of right hydronephrosis. Hydronephrosis is defined as distention of the renal calyces and pelvis with urine as a result of obstruction of the outflow of urine distal to the renal pelvis. Hydronephrosis was graded as mild, moderate, or severe. Mild hydronephrosis was defined as dilatation of renal pelvis and calyces with preservation of the parenchyma. Moderate hydronephrosis was defined as moderate dilatation of the renal pelvis and calyces. None of our patients had severe hydronephrosis.

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Analogously, hydroureter is defined as a dilation of the ureter. Associated clinical and laboratory features (renal colic, impaired renal function, leukocytosis, and erythrocyturia) were documented.

Statistical analysis included descriptive analysis (mean, median, and range), standard deviation for continuous variables, proportions for discrete variables, and comparative tests (chi-square for discrete variables and *t*-test for continuous variables). Statistical analyses were performed using IBM Statistical Package for the Social Sciences statistics software, version 20 (SPSS, IBM Corp, Armonk, NY, USA). All statistical tests were two-tailed and a *P* value of 0.05 was considered statistically significant.

## RESULTS

Of the total 1092 patients, laparoscopic surgery was performed in 190 patients (17.4%), and 902 patients (82.6%) underwent open surgery. Table 1 summarizes patient clinical characteristics. Preoperative imaging (ultrasound or computed tomography) were not performed in 498 patients (45.6%), leaving 594 patients (54.4%) available for analysis. Of the 594 patients with available imaging, 21 patients (3.5%) were diagnosed with mild (13) to moderate (8) right hydronephrosis. Ten of the 21 patients (47.6%) were pregnant women in their second (5) and third (5) trimester. No ureteral concrement was demonstrated in any of the patients. Sonographic “jets” were seen in both ureters in all the patients who had a presurgical ultrasound test. Costovertebral tenderness was noted in all patients. Erythrocyturia was present in 15/21 patients (71.4%) and absent in 6 patients (28.6%). Table 2 summarizes demographic, imaging, and laboratory data of the 21 patients with

right hydronephrosis. Three out of the 21 patients (14.3%) had laparoscopic surgery. Mean surgery duration and hospitalization time in the 21 patients with hydronephrosis was similar to that reported in their non-hydronephrotic counterparts:  $50.7 \pm 27.3$  minutes and  $3.8 \pm 2.3$  days compared to  $51.6 \pm 21$  minutes and  $3.4 \pm 1.5$  days, respectively, ( $P = 0.87$  and  $P = 0.4$ ). Retrocecal appendix was found in 15/21 patients (71%) with right hydronephrosis. Periappendicular abscess was demonstrated in 4/21 patients (19%) and perforation occurred in one patient only (4.7%) [Figure 1]. None of the patients had right ureteral injury demonstrated during surgery. No postoperative complications were witnessed in these 21 patients.

Following surgery, all patients underwent ultrasound examination 2 weeks after discharge and no hydronephrosis was found. Moreover, 15/21 patients (76.2%) had ultrasound examination over the years for various reasons and no hydronephrosis demonstrated in either kidney. Median follow-up time was 41.7 months (range 14.8–118.4 months).

## DISCUSSION

Genitourinary presentation of appendicitis is mentioned in textbooks and there are case reports forewarning the reader of its occurrence and the risk of delayed diagnosis and treatment of appendicitis [9]. The location of the appendix may vary considerably, and at times, urologic symptoms may predominate [10]. These symptoms can include renal or ureteral colic, costovertebral tenderness, frequency, dysuria, anuria, and urinary retention. Lower urinary tract manifestations of acute

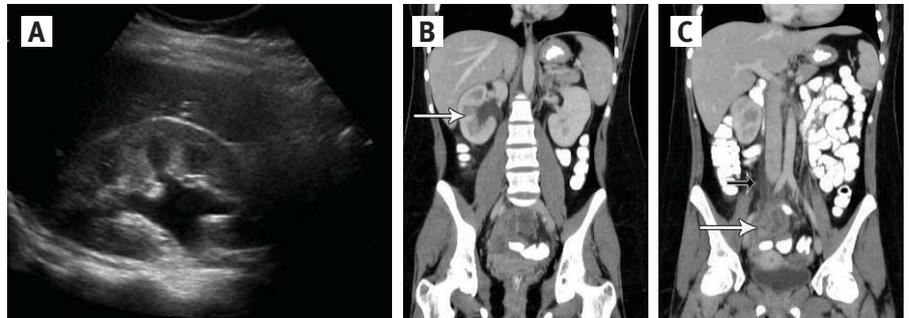
**Table 1.** Basic demographic and surgical data of all patients

Characteristics	Value
Number of patients	1092
<b>Median age, years (range)</b>	31.3 (18–96.7)
Male	31.3 (18.1–90.8)
Female	31.4 (18–96.7)
<b>Gender</b>	
Male	580 (53.1%)
Female	512 (46.9%)
<b>Imaging modality</b>	
None	498 (45.6%)
Ultrasound	482 (44.1%)
Computed tomography	112 (10.3%)
<b>Surgery</b>	
Laparoscopic	190 (17.4%)
Open	902 (82.6%)
<b>Surgery outcome</b>	
True appendicitis	954 (87.4%)
Normal appendix	138 (12.6%)
<b>Erythrocyturia</b>	
Positive	531 (48.6%)
Negative	561 (51.4%)

**Table 2.** Basic demographic, imaging, and laboratory data for patients with right hydronephrosis and acute appendicitis

Characteristics	Value
Number of patients	21
Pregnant	10
Not pregnant	11
<b>Median age, years (range)</b>	
Pregnant	32 (18–87)
Not pregnant	41 (1–87)
<b>Gender</b>	
Male	4 (19%)
Female	17 (81%)
<b>Hydronephrosis diagnosed by</b>	
Ultrasound	16 (76%)
Computed tomography	5 (24%)
<b>Right hydroureter present</b>	6/21 (28.5%)
Not pregnant	5/11 (45.5%)
Pregnant	1/10 (10%)
<b>Erythrocyturia</b>	15/21 (71.4%)
Not pregnant	10/11 (91%)
<b>Laparoscopic surgery</b>	3 (14.3%)
Open surgery	18 (85.7%)
<b>Median follow-up until latest ultrasound test, months (range)</b>	41.7 (14.8–118.4)

**Figure 1.** A 19 year old woman with right flank pain radiating to her right lower quadrant with leukocytosis and microscopic hematuria. **[A]** Abdominal ultrasound demonstrating right hydronephrosis with right hydroureter, **[B]** CT scan with coronal reconstruction demonstrating right hydronephrosis (white arrow), **[C]** CT scan with coronal reconstruction demonstrating hydroureter (black arrow) with acute appendicitis and peri-appendicular abscess (white arrow)



CT = computed tomography

appendicitis may falsely suggest cystitis, a bladder mass, or prostatitis. Men may have pain in the scrotum, while women have been reported to have acute appendicitis associated with cervical motion tenderness and adnexal pain or masses that could suggest ovarian torsion [9]. Abnormal urinalysis may appear in up to 48% of patients with hematuria, pyuria, and albuminuria [11-14]. These clinical features have been reported to manifest most probably due to an inflamed or ruptured appendix, which lies adjacent to the urinary tract. There have been reports of the same bacterial strain grown from urinary and appendiceal cultures. It is believed that the bacteria disseminates from the appendix to the posterior peritoneal cavity and into the urinary tract [8]. If a cluster of these urologic findings dominates the clinical presentation and subsequent ultrasound scans show hydronephrosis without clear evidence of acute appendicitis, this may further mislead the physician toward a diagnosis of a primary urinary tract disease and delay establishing the proper diagnosis.

There are only a few case reports documenting the occurrence of hydronephrosis secondary to acute appendicitis in adults as well as in children [6,14-18]. Cook [15] described the largest series of complete obstruction of the right ureter at the pelvic brim in 6/93 children with appendiceal abscess.

In our cohort of 21 patients, periappendicular abscess was present in less than 20% of the patients and perforation occurred in one patient only, but in 15/21 patients (71%) a retrocecal appendix was demonstrated.

The exact pathogenesis of secondary hydronephrosis in appendicitis is unclear; however, the most likely explanation is direct extension of the inflammatory process through the posterior parietal peritoneum resulting in segmental ureteral ileus, much like bowel ileus, seen with peritonitis [14]. This suspected etiology is even more intuitive when the appendix is retrocecal and is located much closer to the right ureter. Hydronephrosis has also been reported in Crohn's disease of the small bowel [19]. It is of interest to note that there have been reports of both ureters involved in pelvic abscesses from a ruptured appendix [18,20-22]. The proposed mechanism for bilateral ureteral involvement is persisting localized peritonitis at the level of the bladder base, including trigonal edema. This

condition can lead to bilateral ureteric obstruction and anuria [21]. Sometimes the inflamed pelvic appendix can adhere to the urinary bladder, culminating in cystitis-like symptoms or external compression by the abscess. In extreme cases a fistula may form between the appendix and bladder [23].

The hydronephrosis, however, is not specific for acute appendicitis and can be seen with arterial crossing, ureteral obstruction due to a ureteral concrement, pelvic masses, urinary tract infection, disturbance of peristalsis secondary to generalized peritonitis, or retroperitoneal inflammation, including pregnancy [6], as was seen in 10/21 of our patients.

Ureteral concrement is a non-appendicitis related etiological reason for hydronephrosis, causing renal or ureteral obstruction and at times manifesting as colicky pain. Ureteral concrement was not demonstrated in the imaging of any of our patients. Moreover, no apparent evidence of an intraluminal ureteral obstruction was seen in patients who had undergone either a computed tomography or an ultrasound imaging scan. All patients who underwent an ultrasound imaging scan demonstrated sonographic "jets," ruling out any intraluminal obstruction.

Physiologic hydronephrosis of pregnancy occurs in 70–90% of pregnant women by the third trimester, which is more prominent on the right side. It is due to a combination of mechanical obstruction from an enlarged uterus and relaxation of the smooth muscle of the urinary collecting system due to the influence of progesterone [24]. Almost 50% of the patients in our cohort with right hydronephrosis and acute appendicitis were pregnant women. The process of physiologic hydronephrosis of pregnancy undermines the assumption that the hydronephrosis in these patients was secondary to acute appendicitis. However, 2 weeks after the appendectomy and before giving birth, hydronephrosis was resolved according to ultrasound examination. Therefore, we assumed that the hydronephrosis of the pregnant patients in our cohort was secondary or worsened by the process of appendicitis.

To the best of our knowledge, our series of 21 patients with documented right hydronephrosis secondary to acute appendicitis, albeit very small, still represents the largest study reported thus far. It is important to remember that only 54.4% of all

patients in our database had an imaging scan prior surgery. Therefore, in more than 45% of patients diagnosed with acute appendicitis we are clueless as to the proportion of secondary hydronephrosis.

Puskar and colleagues [13] described the disappearance of pyelocaliceal dilatation of the right kidney on postoperative day 6 in all patients manifesting with dilatation prior undergoing appendectomy. Supposedly, the surgical removal of the appendix eliminates the primary site of inflammation and thus enables spontaneous convalescence of the urinary tract. All of our patients underwent ultrasound examination 2 weeks after discharge and showed the disappearance of right sided hydronephrosis, similar to the findings showed by Puskar and co-authors.

This study has several limitations, including the retrospective design, the selection bias of only patients who had imaging, the small number of patients with hydronephrosis, and the fact that all data came from a single, high volume institution.

## CONCLUSIONS

Our study shows that in 3.5% of patients undergoing appendectomy, right hydronephrosis secondary to acute appendicitis was demonstrated. Our results show that although this presentation is very rare, physicians should be aware of this phenomenon and the resulting risk it can cause for delayed diagnosis and treatment of acute appendicitis.

## Correspondence

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## Capsule

### Cancer organoids to model therapy response

Cancer organoids are miniature, three-dimensional cell culture models that can be made from primary patient tumors and studied in the laboratory. **Vlachogiannis** and co-authors asked whether such “tumor-in-a-dish” approaches can be used to predict drug responses in the clinic. They generated a live organoid biobank from patients with metastatic gastrointestinal cancer who had previously been enrolled in phase I or II clinical

trials. This biobank allowed the authors to compare organoid drug responses with how the patient actually responded in the clinic. Encouragingly, the organoids had similar molecular profiles to those of the patient tumor, reinforcing their value as a platform for drug screening and development.

*Science* 2018; 359: 920  
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