# Comparison between Color Doppler Ultrasonography and Computed Tomography for the Diagnosis of Ureteropelvic Junction Obstruction

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**Abstract**

**Introduction and Objectives.** Ureteropelvic junction obstruction (UPJO) is one of the common causes of hydronephrosis with an estimated incidence of about 1:1500 newborns. It is defined as a functional obstructive condition caused by the development of abnormalities in the smooth muscle and the innervation of the pyeloureteral junction. The aim of this study is to assess the utility, sensitivity and specificity of color Doppler ultrasonography in diagnosing the ureteropelvic junction obstruction with crossing vessel, compared with multidetector CT angiography examination.

**Materials and Methods.** Our study included 52 patients (30 female patients; 22 male patients) with ages between 19-58 years, diagnosed with ureteropelvic junction obstruction by ultrasound examination with Color Doppler Imaging and multidetector CT examination. All patients received surgical treatment (open, laparoscopic or robotic techniques) and the imaging diagnosis was compared with the intraoperative findings.

**Results.** Out of the 52 patients examined 42 had UPJO caused by crossing vessels(80.76%), while 10 had modified anatomy – junction adhesions (19.24%). Color Doppler ultrasound detected 41 patients with ureteropelvic junction obstruction due to crossing vessels and 11 patients with the same diagnosis produced by junction adhesions: sensitivity - 97.6%; specificity - 100%. CT examination detected 44 patients with obstruction caused by crossing vessel and only 8 patients with pelvic junction adhesions: sensitivity - 100%; specificity - 80%. The positive predictive value for color Doppler ultrasound examination was 100% whereas for multidetector CT examination was 95.5%.

**Conclusions.** Color Doppler ultrasound imaging is a cheap, non-invasive, non-irradiating method to diagnose UPJO caused by crossing vessels. Compared with CT examination we found that color Doppler ultrasound accuracy is at least similar thus making it suitable as first investigation for suspected UPJO. The uroCT examination is still one of the crucial investigations for surgical planning.

**Key-words:** color Doppler ultrasound, crossing vessel, ureteropelvic junction obstruction, uroCT.

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## Introduction and Objectives

Ureteropelvic junction obstruction (UPJO) is one of the common causes of hydronephrosis with an estimated incidence of about 1:1500 newborns. It is defined as a functional obstructive condition caused by the development of abnormalities in the smooth muscle and the innervation of the pyeloureteral junction. This anomaly disturbs the normal peristalsis of the ureter which impairs the normal flow of urine from the renal pelvis into the ureters [1,2]. UPJO usually appear secondary to an intrinsic or extrinsic abnormality of the junction. The intrinsic abnormalities include: inadequate smooth muscle or nerve development at pyeloureteral level, altered neurotransmission, high ureter insertion to renal pelvis and persistent fetal folds. The extrinsic abnormalities include aberrant crossing vessels, kidney rotation, retrocaval ureter or malformations of the upper urinary tract like ureteropelvic duplicity [1-3].

The presence of a crossing vessel that supplies the lower pole of the kidney is the most encountered vascular malformation that produces a mechanical obstruction of the ureteropelvic junction [4,5]. The crossing vessel is important in the pathology and surgical treatment of UPJO for choosing the proper surgical technique and for the recognition of a potential source of hemorrhage during surgery 6.

UPJO is diagnosed by imaging tests which include ultrasound examination (plain and color Doppler), computed tomography (CT), magnetic resonance imaging (MRI) which could be completed by contrast arteriography or endoluminal ultrasonography [6, 7].

The purpose of this study is to assess the utility, sensitivity and specificity of color Doppler ultrasonography in detecting UPJO with crossing vessel, compared with uroCT examination.

## Materials and Methods

*Study population*

Our study included 52 patients (30 female patients; 22 male patients) with age between 19-58 years (mean age – 35.87 years), admitted in our clinic in the last 5 years (Jan 2012 – Dec 2016). All patients were diagnosed with UPJO by means of color Doppler ultrasound examination and CT scan with contrast enhancement. The ultrasound examination revealed dilation of the renal pelvis and calices. Not all patients were symptomatic at the moment of diagnosis: in 32 out of 52 patients the diagnosis of UPJO was incidentally established during a routine control. All patients received surgical treatment either by open techniques or by laparoscopic and robotic surgical techniques.

*Simple Ultrasound and Color Doppler Imaging*

All the sonographic examinations were made using two types of ultrasound systems: Siemens Sonoline Versa Pro and BK Flex Focus 500. Both systems detected hydronephrosis caused by crossing vessel (marked out in Doppler and Power Doppler mode) or by adhesions in the ureteropelvic junction. We were also able to assess the renal parenchyma related to the degree of obstruction and hydronephrosis.

*Multidetector CT angiography examination*

All patients were examined by uroCT means using a contrast substance that examined arterial, venous and excretory phases. With CT scan we were able to examine the status of renal parenchyma and kidney orientation, grade of hydronephrosis, presence of the crossing vessel, position of the vessel (anterior or posterior) in relation with ureteropelvic junction and number of crossing vessels. In some cases were there was found an important hydronephrosis, the kidney function assessment was completed by renal scintigraphy.

*Data analysis*

The data obtained from ultrasonography examination were compared with those obtained from CT examination in terms of detection rate and ability to detect crossing vessels. All patients received surgical treatment (open, laparoscopic or robotic Hynes-Anderson or Foley Y-V pyeloplasty) and the results obtained by imaging examinations were compared with intraoperative aspects. Using those means we calculated the predictive value, sensitivity and specificity of the ultrasound compared with CT in diagnosing UPJO using SPSS statistics software.

## Results

Our study included 52 patients with UPJO caused by crossing vessel (n=42, 80.76%) and modified anatomy - adhesions (n=10, 19.24%). 30 patients had right sided UPJO (58%), while 22 patients had left sided obstruction (42%). Onlysome patients were symptomatic at diagnosis moment: only 20 patients (38%) presented with lumbarpain, while 32 patients (62%) had never experienced symptoms -these patients were diagnosed incidentally during a routine examination. Nine patients had also renal comorbidities like acute pyelonephritis (n=4, representing 8%) and lithiasis (n=5, repre-

senting 9%), most probably caused by the obstructive syndrome. Patients that were diagnosed with kidney stones and infections had ages between 24 and 58 years with a mean age of 42.5 years.

*Simple Ultrasound and Color Doppler Imaging*

By simple ultrasound examination we could evaluate the presence and grade of hydronephrosis and also the status of renal parenchyma. We found that all patients had one sided hydronephrosis with grade ranging between 2 and 4, according to the ultrasound grading of hydronephrosis (Table 1)[8,9].

*Table 1 – Ultrasound grading of hydronephrosis[8,9]*

| Grade of Hydronephrosis | Characteristics |
|---|---|
| Grade I | Dilatation of the renal pe vis without dilatation of the calices. No signs of prenchymal atrophy. |
| Grade II | Dilatation of the renal pelvis and calices. No signs of parenchymal atrophy. |
| Grade III | Dilatation of the renal pelvis and calices. Minor signs of parenchymal atrophy. |
| Grade IV | Massive dilatation of the renal pelvis and calices. Borders between renal pelvis and calyces are missing. Significant signs of renal atrophy. |

Most patients had 3rd grade hydronephrosis (62%, n=32) while 14 patients had 2nd grade (27%) and the rest of 6 had 4th grade (11%). We have also evaluated the thickness of the renal parenchyma in order to assess the degree of renal impairment caused by hydronephrosis. We found that only in 6 cases of 3rd grade hydronephrosis the renal parenchyma was thinner than the opposite kidney and in all 4th grade hydronephrosis the renal parenchyma was considerably thinner. For the 6 patients with 4th degree hydronephrosis we recommended renal isotope scintigraphy which demonstrated that excretory function was still present, so that kidney function still had chances of recovery after pyeloplasty.

*Figure 1 – Grade 3 hydronephrosis in an uretero-pelvic junction obstruction syndrome*

Concerning crossing vessels we found that 41 out of 52 patients had crossing vessels (78,84%) and 29 of them had a single vessel (artery). Double vessels were detected in 12 patients (artery and vein)located anteriorly to the ureteropelvic junction.

*Figure 2 – Crossing vessel at the uretero-pelvic junction detected with Color Doppler ultrasound*

*CT angiography examination*

At CT examination 44 patients out of 52 were diagnosed with lower pole crossing vessels while only 8 were diagnosed with UPJO caused by adhesions. Out of the 44 patients mentioned above, 32 had a single crossing vessel (artery) while 12 had double vessels (artery and vein). From the total of 44 crossing vessels 26 arteries were described as inferior accessory renal arteries and 18 arteries as inferior segmental branches of the renal artery.

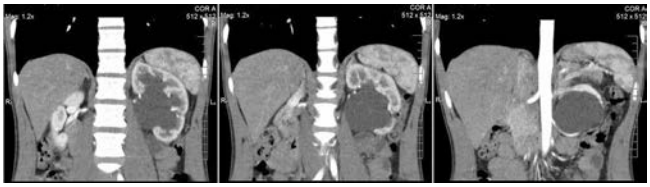
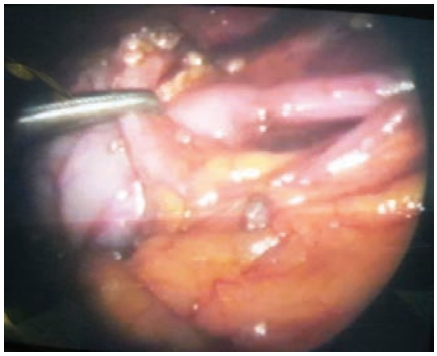


*Figure 3 – Left crossing vessel detected in CT examination*

*Intraoperative findings*

All 52 patients had operatory indication and underwent surgical treatment – Hynes-Anderson or Foley (Y-V) pyeloplasty. Open pyeloplasty was performed in 33 patients with UPJO. 24 patients had junction syndrome produced by crossing vessels while the other 9had junction adherences. Out of the 24 patients diagnosed with crossing vessels that underwent open surgery 10 patients had double vessels located anterior. Hynes-Anderson or dismembered pyeloplasty was performed to the patients that had crossing vessels (n=24) while to the rest of 9 patients we performed Foley pyeloplasty. 18 patients underwent laparoscopic pyeloplasty, among them only one had junction syndrome produced by adherences and the rest of 17 had crossing vessels. Two patients had double vessels (artery and vein) located anteriorly to ureteropelvic junction. These 17 patients underwent Hynes-Anderson pyeloplasty while to the patient that had adhesions we performed Foley pyeloplasty. The patient that was operated robotic had one crossing vessel and we performed Hynes-Anderson pyeloplasty.



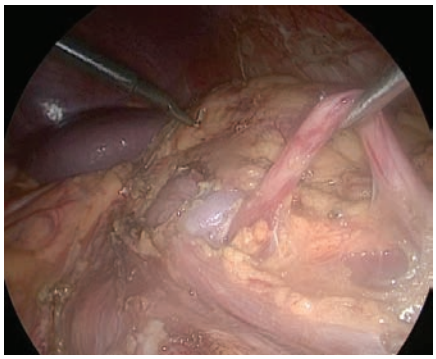


*Figure 4, 5 – UPJO with crossing vessel – laparoscopic Hynes-Anderson pyeloplasty*

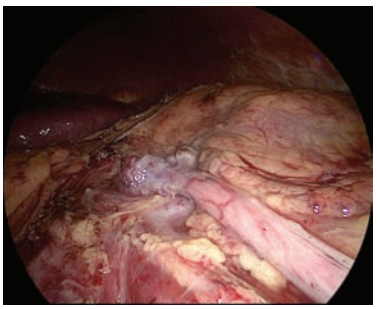


*Figure 6 – Pelvi-ureteral anastomosis in Hynes-Anderson pyeloplasty*

Intraoperative findings revealed that 42 patients had UPJO produced by crossing vessel while 10 patients had the same syndrome produces by junction adhesion. In total a number of 54 vessels were detected intraoperative, which included 42 arteries and 12 veins. Only one vascular injury was reported during an opened Hynes-Anderson pyeloplasty. Out of the 17 patients that underwent Hynes-Anderson laparoscopic pyeloplasty one patient had postoperative recurrence at 6 months due to multiple adhesions at ureteropelvic anastomosis site. The patient had indication of open surgery so that we performed open Hynes-Anderson pyeloplasty.

*Data comparison with intraoperative findings*

The results of ultrasound and CT examination were compared with the intraoperative findings, which served as reference method of diagnosis for the presence, position and type of crossing vessel – Table 2.

Ultrasound examination with color Doppler imaging detected 41 patients with UPJO due to crossing vessels and 11 patients with the same diagnosis produced by pelvic junction adhesions. The intraoperative findings revealed 42 patients with crossing vessels. The type of vessel described in Doppler ultrasound examination (simple artery or artery and vein) was the same type as the vessel found during surgery. Also the position of the crossing vessels described in ultrasound was superposed with intraoperative findings (29 patients had a single vessels - artery - while 12 patients had double vessels - artery and vein).

*Table 2 – Number of vessels found in ultrasound and CT examinations compared with the intraoperative findings*

| | | Color Doppler ultrasound | CT angiography examination | Intraoperative findings |
|---|---|---|---|---|
| Total patients | | 52 | 52 | 52 |
| Patients with crossing vessels | | 41 | 44 | 42 |
| Single vessel | Artery – anterior | 29 | 32 | 30 |
| Double vessels | Artery and vein – anterior | 12 | 12 | 12 |
| Sensitivity of method | | 97.6% | 100% | - |
| Specificity of method | | 100% | 80% | - |

On the statistical analysis performed using data mentioned above we concluded that color Doppler ultrasound examination yielded a sensitivity of 97.6% and specificity of 100% in detecting UPJO due to crossing vessel. The positive predictive value for color Doppler ultrasound examination was also 100%and the negative predictive value was 90.9%.

UsinguroCT examination, 44 patients were diagnosed with obstruction caused by crossing vessel and only 8 patients with pelvic junction adhesions. By comparison with intraoperative findings the CT examination detected 2 extra vessels (arteries located anterior) not found during the surgical procedure. At a postoperative re-examination it was concluded that the vessels described at CT examination were colic arteries superposed to the pelvic junction. The sensitivity of this method was calculated as 100% but the specificity was 80% in detecting UPJO due to crossing vessel. The positive predictive value for CT examination was 95.5% while the negative predictive value was 100%.

**Discussions**

The ureteropelvic junction obstruction due to crossing vessel is one of the most encountered congenital malformations in urology. These vessels supply the lower pole of the kidney and most of the time originates from the renal artery or from the aorta. The treatment of this condition is surgical, whether open, laparoscopic or robotic. Thus the importance of imagistic investigations, which includes Color Doppler Ultrasound, endoluminal ultrasound, CT, MRI, is crucial in planning the surgical approach. One of the most accessible and accurate imaging diagnosis methods is Color Doppler Ultrasonography.

In our study we found that color Doppler ultrasound has a sensitivity of 97.6% and specificity of 100%, for the diagnosis of UPJO in comparison with the intraoperative findings. We compared our results with several studies on the same topic published in medical literature.

Mitterberger et al. studied the accuracy of color Doppler ultrasound with contrast enhancement compared with CT and MRI. In a group of 48 patients diagnosed with UPJO they found that 44 patients had crossing vessels, diagnosed with color Doppler ultrasound, with various positions related to the ureteropelvic junction. The same results regarding the presence and position of the crossing vessels were detected intraoperative during laparoscopic pyeloplasty, so they found that color Doppler ultrasound had an accuracy of 100%. The conclusion of Mitterberger's study was that color Doppler imaging is recommended as first-line imaging modality for the detection of crossing vessels in patients with UPJO [6]. Frauscher et al. tried to study whether the contrast enhanced color Doppler ultrasound is better than simple color Doppler ultrasound. They found 23 patients with crossing vessels out of a total of 29 patients with UPJO. The preoperative diagnosis was established using color Doppler imaging with and without contrast enhancement. On contrast enhancement Doppler imaging 22 patients were diagnosed with crossing vessels compared with 15 patients diagnosed using non-contrast enhancement Doppler imaging. The accuracy of contrast enhanced color Doppler was 97% compared with 73% accuracy of non-contrast enhanced color Doppler [7]. Sharma et al. found on a series of 18 patients of UPJO with crossing vessel that color Doppler ultrasound had a sensitivity of 40% compared with angiographic CT which had a sensitivity of 100%. In their conclusion is stated that angiograph CT is the investigation of choice for the UPJO with crossing vessel [10].

Similar conclusions about the role and utility of color Doppler ultrasound in detecting crossing vessels were also found in pediatric patients. Rigas et al. found on a series of 71 patients that ultrasound imaging among other investigations is very important for the diagnosis of UPJO and that color Doppler ultrasound could help to establish the diagnosis of UPJO with crossing vessel [11].

Many other publications demonstrated and stated the crucial role of ultrasound in detecting the hydronephrosis caused by UPJO [12] and especially color Doppler ultrasound for evaluating the presence of crossing vessels at ureteropelvic junction site and also the usefulness of other ultrasound features like power Doppler or the measurement of the renal arteriolar resistivity index [1, 3].

For CT examination with contrast enhancement we found that sensitivity in detecting ureteropelvic junction crossing vessels was 100% but specificity was estimated to 80% with a positive predictive value of 95.5%. Xie et al. found that accuracy for CT examination in detecting UPJO of 85.2%. The study was conducted on 61 patients with junctional syndrome and was a comparison with the accuracy of intravenous urography [13]. El-Nahas et al. found 33 patients with crossing vessels from a total of 60 patients with UPJO, that were diagnosed by CT angiography and compared with the intraoperative findings. They found for CT examination a

sensitivity of 97%, a specificity of 92% and an accuracy of the method of 96%[14]. Parks et al. demonstrated that CT angiography is less invasive in comparison with angiography and the 3D image reconstruction of the helical CT angiography brings very accurate information about the crossing vessels[15].

## Conclusion

In conclusion color Doppler ultrasound examination is a valuable investigation in the diagnosis of ureteropelvic junction obstruction due to crossing vessel and it should be used as first investigation for UPJO. We found that color Doppler ultrasound accuracy in terms of sensitivity for detecting crossing vessels has close similarities touroCT examination.Thus we concluded that Color Doppler ultrasound imaging represents a cheap, non-invasive, non-irradiating method forthe diagnosis of UPJO caused by crossing vessels. Although there are clear advantages of Doppler ultrasound, uroCT examination (including angiography and 3D reconstruction)has a pivotal role for UPJO surgical treatment.

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