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Diagnostic value of the resistive index and ureteral jets in renal colic: case-control study.

Valeur diagnostique de l’index de résistance et des jets urétéraux dans la colique néphrétique : étude cas-témoins.

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Mots-clés: Index de résistance, jets urétéraux, colique néphrétique, lithiase.

Keywords: Resistive index, ureteral jets, renal colic, nephrolithiasis.

*Résumé

Objectifs: Evaluer l’apport de l’écho-Doppler dans le diagnostic et le choix thérapeutique de la colique néphrétique.

Matériels et méthodes: Il s’agissait d’une étude cas-témoins chez des sujets présentant une colique néphrétique unilatérale. L’uroscanner était l’examen de référence. L’étude statistique a été réalisée par les tests d’ANOVA et de corrélation de Pearson. Un p < 0,05 était significatif.

Résultats: On notait une forte corrélation positive entre le diamètre antéro-postérieur du pyélon et l’index de résistance (IR) des reins atteints (r = 0,59). Les moyennes des IR des reins atteints et des reins sains étaient respectivement de 0,69 ± 0,07 et 0,55 ± 0,05 (p = 0,0005). L’écho-Doppler, un obstacle complet était plausible si les jets urétéraux étaient absents pendant 5 minutes soit dans 9,7%. La sensibilité et la spécificité d’une IR ≥ 0,7 dans le diagnostic d’obstruction urinaire aiguë étaient respectivement de 22,6% et 100%; celles de ΔIR ≥ 0,05 étaient de 100% chacune.

Conclusion: La mesure de l’IR permet de poser le diagnostic de l’obstruction urinaire aiguë. L’absence de jets urétéraux pendant 5 minutes est synonyme d’obstacle complet.

ABSTRACT

Objectives: To assess the contribution of Doppler ultrasound in the diagnosis and therapeutic choice of renal colic.

Materials and methods: Case-control study, the Group 1 consisted of patients presenting a unilateral renal colic. Asymptomatic patients represented group 2. The CT urography was the gold standard. Statistical analysis was performed by ANOVA test and Pearson correlation. A p <0.05 was significant.

Results: There was a good positive correlation between the pyelon posteroanterior diameter and RI of affected kidney (r = 0.59). The means of diseased and healthy kidneys RI were respectively 0.69 ± 0.07 and 0.55 ± 0.05. The difference was statistically highly significant; p = 0.0005. A complete obstacle was plausible if ureteral jets were absent during 5 minutes at Doppler ultrasound (9.7%). The sensitivity and the specificity of RI ≥ 0.7 in the diagnosis of acute urinary obstruction were respectively 22.6% and 100%; those of ΔRI ≥0.05 were 100% each.
1. Introduction
The acute urinary obstruction syndrome is defined as a brutal, partial or total obstacle to urine flow. It is a frequent pathology because of the length and the tight caliber of the urinary tract. [1]. Its diagnostic relies on demonstrating an increase intra-cavity pressure above the obstacle [2]. This increase intra-cavity pressure can be measured in medical imaging by the resistive index of inter-lobar arteries (RI) during the 6-48h after the beginning of the symptoms. [2, 3].
In the West and many emergent countries in Asia, many studies have shown normal (0.5 to 0.7) and pathological values of the RI [2-8]. A reliable appreciation of a renal obstruction and its functional repercussion condition the care of the patient.
In few medicalized countries, to our knowledge, no study has established normal values of the RI and the contribution of Doppler ultrasound in acute urinary tract obstruction. So we found proper to undertake this study which objectives were to establish the values of renal RI in normal Togo people, and assess the contribution of Doppler ultrasound in the diagnosis and therapeutic choice of lithiasic renal colic.

2. Materials and methods
It was a case-control study led on six months (January to June 2015) in a black population. Forty-eight (48) patients were received for renal colic during the study period. We have included in the study, patients from both sex, and aged of at least 18 years, addressed to the Radiology Department for a unilateral renal colic lasting for less than 2 days (6-48h).
Non-inclusion criteria were personal record of “ascendant” or vascular nephropathy, cardiac arrhythmia and the use of non-steroidal anti-inflammatory drugs. Were excluded from the study, the patients who have presented a stenosing lesion of a renal artery on the Doppler ultrasound, an arterio-venous fistula on dialyzed patient. So, 31 patients have formed the group 1 (G1) or sick-group and the group 2 or control-group has gathered 31 asymptomatic people meaning 31 affected and 93 normal kidneys explored.
The devices used were ultrasound systems labeled ALOKA ProSound 5500 and a VOLUSON E6 BT10 of General Electric, all provided with a sectorial transducer of 3.5-5 MHz. The exams were performed by one and the same operator to avoid eventual variation between various operators. On the Doppler ultrasound, we have measured the pyelon posteroanterior diameter (PAD), the RI and studied the ureteral jets in a bilateral and comparative way. The RI were measured on the same type of artery at the upper pole, in the convex region and at the lower pole of each kidney and an average value was calculated.
The retained lesion diagnostic criteria were: a RI ≥ 0.7 or a RI difference between the kidneys of the same person ( ΔRI ) ≥ 0.05; a PAD > 10 mm, an absence of ureteral jets, an asymmetric orientation unexceeding the middle line, intervals between two same side jets > 150 s and a duration of jets < 15 s. The gold standard used was the Bright speed 16 barrettes scanner of General Electric. Calculus were diagnosed with the echography and with the CT urography in all the patients of G1. The complete obstacle was defined on the CT urography by a lack of opacification of a ureteral segment below the obstacle one hour after the injection of contrast agent.
Qualitative data were treated with Microsoft Word 2007 and Microsoft Excel 2007. The statistical analysis was performed by ANOVA tests and Pearson correlation. A p<0.05 was considered as significant.

3. Results
The mean ages were 39.84 years ± 15.87 and 40.26 years ± 13.45 respectively in the sick and control group; the difference was not statistically significant ( p = 0.90). The extreme ages were 18-74 years and 18-75 years respectively in G1 and G2. In both group, there was a male predominance (22 men versus 9 women, sex-ratio = 2.44). In G1, the affection was right-localized in 19 cases (61.2%) and at the left in 12 cases (38.8%).
The mean pyelon PAD of diseased and non-diseased kidneys were respectively of 10.83 mm ± 1.99 and 5.12 mm ± 1.64; the difference was statistically extremely significant ( p = 0.0001). The pyelocaliceal cavities were dilated in 17/31 cases (54.84%). The difference between the pyelon PAD of affected and non-affected kidneys was not statistically significant according to the age ( p = 0.95) and the sex ( p = 0.78). There was a good positive correlation between the pyelon PAD and RI of affected kidneys (r = 0.9).
In the G1, affected kidneys showed up a RI ≥ 0.7 in 7 cases (22.58%) and a ΔRI≥ 0.05 was observed in 31 cases (100%). The mean ΔRI was 0.13 ± 0.06 in G1 whereas it was 0.02 ± 0.007 in G2; the difference was statistically very significant ( p = 0.01). Figure 1 shows a ΔRI≥ 0.05 between both kidneys of the same person.
The means RI difference between affected kidneys (0.69 ± 0.07) and normal kidneys of G1 (0.56 ± 0.06) was statistically extremely significant; p = 0.0004. The difference was also statistically extremely significant

Conclusion: The measurement of RI (especially ΔRI) is a non invasive and not radiating means to the diagnosis of acute urinary tract obstruction. The absence of ureteral jets during 5 minutes means total obstacle.
between affected and non-affected kidneys of G2 (0.55 ± 0.06); p = 0.0007. In sum, the means RI of affected and non-affected kidneys were respectively 0.69 ± 0.07 and 0.55 ± 0.05 (p = 0.0005). There was no difference statistically significant between the mean RI in normal kidneys of people from G1 and from G2 (p = 0.87). In G2, the increase of the RI was weakly correlated in a positive way with the age (r = 0.13) while it was not with the sex (r = 0.00).

 Modifications of ureteral jets (figure 2) were observed in 12 cases (38.71%) in G1. Table I shows RI according to the presence or not of ureteral jets modifications in G1. In 3 cases (9.7%), Doppler ultrasound has shown an absence of ureteral jets over a period of 5 minutes. This was confirmed on the CT scan by an interruption of contrast agent at the level of the obstacle. The difference between the mean RI whether the obstacle was complete or not was not statistically significant; p = 0.03. Table II relates the correlation between the absence of ureteral opacification below the obstacle on the CT scan and the absence of ureteral jets according to the time on the Doppler ultrasound. Figure 3 shows a partially obstructive ureteral iliac lithiasis on the CT scan.

Figure 1: 37 years old man presenting a right renal colic. Doppler ultrasound aspect of a ΔRI>0.05. G) left kidney. D) right kidney.

Figure 2: 39 years old man presenting a right renal colic. The Doppler ultrasound has shown a ureteral jets asymmetry characterized by an orientation anomaly of the right ureteral jet (arrow) in an intra-mural incomplete obstacle.

Figure 3: 42 years old woman presenting a left renal colic. CT scan aspect, VR reconstruction of left uretero-hydronephrosis in stage 1, secondary to a partially obstructive lithiasis (arrow).

The sensitivity of ΔRI≥ 0.05 was superior to the one of a RI ≥ 0.7 in the diagnosis of acute urinary obstruction syndrome whereas their specificities were equals (100%). Table III summarizes the comparison of the
informative value of $RI \geq 0.7$ and of $\Delta RI \geq 0.05$ in the diagnosis of acute urinary obstruction.

On the basis of the study of ureteral jets, confirmed on the CT urography, the three patients who had a complete obstacle had benefit from an emergency surgical care to remove the obstacle. The other 28 patients having an incomplete obstacle had received a medical treatment based on antalgic and anti-inflammatory drugs. There was a favorable evolution in all the cases.

### Table I. Resistive index (RI) value according to the presence or not of ureteral jets modifications in group 1.

<table>
<thead>
<tr>
<th>Ureteral jets modifications</th>
<th>N (%)</th>
<th>RI (Mean ± SD)</th>
<th>$\Delta RI$ (Mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>12 (38.71)</td>
<td>0.70 ± 0.04</td>
<td>0.13 ± 0.08</td>
</tr>
<tr>
<td>Absent</td>
<td>19 (61.29)</td>
<td>0.64 ± 0.05</td>
<td>0.11 ± 0.04</td>
</tr>
<tr>
<td>Absence of ureteral jets</td>
<td>03 (9.7)</td>
<td>0.71 ± 0.03</td>
<td>0.14 ± 0.05</td>
</tr>
<tr>
<td>Asymmetric orientation of the jets</td>
<td>08 (25.81)</td>
<td>0.68 ± 0.04</td>
<td>0.11 ± 0.08</td>
</tr>
<tr>
<td>Intervals between two jets &gt; 150 s</td>
<td>06 (19.4)</td>
<td>0.69 ± 0.06</td>
<td>0.12 ± 0.05</td>
</tr>
<tr>
<td>Jets duration &lt; 15 s</td>
<td>06 (19.4)</td>
<td>0.68 ± 0.05</td>
<td>0.11 ± 0.07</td>
</tr>
</tbody>
</table>

SD: standard deviation; $\Delta RI$: difference between the RI of the same patient kidneys

### Table II. Correlation between the absence of ureteral jets on the Doppler ultrasound and the ureteral opacification below the obstacle on the CT scan.

<table>
<thead>
<tr>
<th>Absence of ureteral jets(n) on Doppler ultrasound</th>
<th>Absence of ureteral opacification below the obstacle (n) on CT Scan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affected side (n)</td>
<td>Normal side (n)</td>
</tr>
<tr>
<td>$\leq$ 2 minutes</td>
<td></td>
</tr>
<tr>
<td>[2, 3 minutes]</td>
<td></td>
</tr>
<tr>
<td>[3, 4 minutes]</td>
<td></td>
</tr>
<tr>
<td>[4, 5 minutes]</td>
<td></td>
</tr>
<tr>
<td>$&gt; 5$ minutes</td>
<td></td>
</tr>
</tbody>
</table>

### Table I. Comparaison between the informative value of $RI > 0.7$ and of $\Delta RI > 0.05$ in the diagnosis of acute urinary obstruction.

<table>
<thead>
<tr>
<th>$RI \geq 0.7$</th>
<th>TP</th>
<th>TN</th>
<th>FP</th>
<th>FN</th>
<th>Se (%)</th>
<th>Sp (%)</th>
<th>PPV (%)</th>
<th>NPV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>07</td>
<td>31</td>
<td>00</td>
<td>24</td>
<td>22.6</td>
<td>100</td>
<td>100</td>
<td>56.4</td>
</tr>
<tr>
<td>$\Delta RI \geq 0.05$</td>
<td>31</td>
<td>31</td>
<td>00</td>
<td>00</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

TP: true positive; TN: true negative; FP: false positive; FN: false negative; Se: sensitivity; Sp: specificity; PPV: positive predictive value; NPV: negative predictive value

### 4. Discussion

The first objective of our study was to assess the contribution of Doppler ultrasound in the diagnosis and therapeutic choice in the lithiasic renal colic. Our results show, on the one hand, that the measurement of RI and especially of $\Delta RI$ allows to set up in emergency a reliable diagnosis of acute urinary obstruction. On the other hand, the study of ureteral jets, particularly its presence or not, allows to select the patients presenting a complete obstacle and needing an emergency surgical care.

The analysis of non-affected kidneys, has allowed us to have values that would be used as reference. The major limits of our study were the small number of studied people and the technical difficulties generally observed on the Doppler ultrasound of obese patients or presenting an important intestinal air stasis [9]. In fact, 31 cases and 31 controls had formed the study groups. Regarding the type of study (case-control), we think those numbers are sufficient to draw valuable
conclusions. Those numbers were inferior to Haroun’s ones [10] who worked with 42 cases and 46 controls. We chose a same number of cases and controls to harmonize the groups and minimize the selection bias, as noticed by the non-significant difference between the mean ages of G1 and G2. Moreover, patients presenting a chronic or bilateral affection, such as those presenting a pathology liable to modify the RI have been voluntarily excluded from the study group. The patients presenting a bilateral affection were not admitted in the study because the ΔRI appreciation would have been difficult as underlined by Giordana and al [11].

On a technical plan, the pathologic threshold retained were: a RI ≥ 0.7 and/or ΔRI≥ 0.05. In the literature, the retained thresholds vary, according to the authors, from 0.65 to 0.70 for the RI and from 0.05 to 0.08 for the ΔRI [2, 3, 10, 12]. Some authors have used in addition a ΔRI≥ 10-11% between both kidneys of the same patient [3, 7]. The gold standard exam used was CT urography. Pepe and al [7] have also used the CT urography when Haroun [11], Granata and al [2] have used intravenous urography. On the other hand, Onur and al [12] have sought for lithiasis with both CT urography and intravenous urography. This allows to perform a morphological and functional study of the urinary apparatus. Both radiological means, lightly invasive, are irradiant contrary to the Doppler ultrasound that shows a great interest in patient having a contra-indication to contrast agent injection or pregnant women mostly at the beginning of the pregnancy.

Mean ages were of 39.84 years (18-74 years) and 40.26 years (18-75 years) respectively in G1 and G2. The extremes of our samples were almost similar to Opdenakker and al’ ones (18-82 years) [3]. Granata and al [2] have found a mean age a little bit superior to the one we have observed in our study, mean 45.6 years. This difference can be due to a greater life expectancy in the population studied by Granata and al [2].

We have noticed a male predominance with a sex-ratio = 2.44 in G1 and G2. This similitude observed between both groups was a voluntary choice of the authors for a harmonization of our samples. Our result corroborate the one of Granata and al [2] who have found a male predominance with a sex-ratio = 2.

The echography has shown a dilatation of pyelocaliceal cavities in 54.84% and the mean PAD of affected kidneys was small (10.83 mm ± 1.99). This result is lightly inferior to the one observed by Onur and al [12] who have found 68% of pyelocaliceal cavities dilatation. This small frequency of dilatation in our study can be explained by the fact that we have excluded the patients presenting chronic pains. It was the first episode and the beginning of the affection for all the diseased kidneys of our study, so it is logic pyelocaliceal cavities could not have time to dilate.

Affected kidneys have presented RI means of 0.69 and a ΔRI of 0.13. Our results are between the ones found in the literature that means 0.664 to 0.71 for the RI and 0.049 to 0.13 for the ΔRI [2, 3, 7, 8, 10]. There was a good correlation between the PAD and the RI (r = 0.59). The addition of the study of the RI and the PAD could allow to increase the diagnostic value of Doppler ultrasound and to make the difference between an obstructive dilatation of urinary tract and a caliceal hypotonia where there is no increase of the intra-cavity pressure.

The mean of RI of normal kidneys of G1 and the one of G2 were respectively of 0.56 ± 0.06 and 0.55 ± 0.06. There was no significant statistical difference. Those values could be used as references in our place where no study have established normal values of RI before. There is no difference with the ones in the literature [2-8] and a racial or socio-demographic factor acting on the RI is to eliminate. The weak positive correlation between the RI and the age, suggests that RI increases with age but not in a significant way.

We have observed 9.7% of ureteral jets’ absence which was evocative of a complete obstacle.

Indeed there is no reference method to stage the gravity of obstruction except a posteriori, but we believe that a complete obstacle is harmful for the renal function if the obstacle is not removed. The demonstration of this complete obstruction is done ideally with the CT urography. Making the diagnosis of the complete obstruction by the study of ureteral jets allows to avoid a medical irradiation. According to some authors, a complete obstacle which has lasted 4-7 days leads to an incomplete recovery of the renal function after the removal of the obstacle [13]. The absence of ureteral jets during a 5 minutes time was synonym of complete obstacle so implying an emergency surgical care to allow an optimal renal function recovery. In our study, the three patients who have presented a complete obstacle had benefit from an emergency surgical care. The 28 other patients had benefit from an antalgic and anti-inflammatory treatment. There was a favorable evolution in all the cases.

The sensitivity of the RI ≥ 0.7 (22.6%) was inferior to the one of ΔRI ≥ 0.05 (100%) whereas their specificities were equals (100%). The ΔRI was the most useful value as underlined by many authors [2-8, 13, 14].

5. Conclusion
The measurement of RI is a non-invasive and non-irradiant mean allowing to make the diagnosis of acute obstruction of urinary tract. ΔRI being the most useful value. Prior to this measurement is the control of the other factors liable to modify the RI. The absence of
ureteral jets during 5 minutes is synonym of complete obstacle and justifies an emergency surgical care to remove the obstacle and allow an optimal renal function recovery.

**Competing interests**
The authors declare that they have no competing interests.

6. **References**