Follow-up of acute pyelonephritis: does the clinical recovery coincide with DW-MRI recovery?

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Aims and objectives

Contrast-enhanced computed tomography (CT) is the gold standard for diagnosis of APN and its complications [1], but it is associated with an amount of radiation that may be potentially dangerous (especially for young women and infants), as well as with the risk of contrast medium-induced nephropathy (more frequent in older people).

Contrast-enhanced Magnetic Resonance was proven to be a valid alternative to CT in terms of sensitivity and specificity. [2] Several studies fostered the emerging role of DW-MR in confirming a clinical suspicion of APN and impacting treatment decisions. [3-7] In particular a study on native kidneys [3] identified three Apparent Diffusion Coefficient (ADC) value brackets corresponding to healthy parenchyma, APN foci and abscesses, suggesting that ADC maps could be a reasonable alternative to contrast-enhanced MR imaging.

It was also emphasized that imaging is important for confirming treatment effectiveness during follow-up. [2,4,8-10] However, there are few data about the DW-MRI evolution of APN foci and its correlation with clinical status and laboratory parameters. We therefore planned a prospective comprehensive study to analyse the role of DW-MRI in the follow-up of APN.
Methods and materials

18 young (35.6±9.7 years) women with clinical, laboratory (high white blood cell and C-reactive protein) and DW-MRI (4b-values of 0, 50, 600, 1000 s/mm$^2$) diagnosis of APN were prospectively enrolled and scheduled to undergo two check-up sessions: the first after one month, at the end of the antibiotic treatment prescribed by nephrologists, the second after 3 months, when full recovery was to be expected.

All MR examinations were performed at 1.5 T (Achieva, version 2.6, Philips Medical Systems, Eindhoven, The Netherlands) with body coil phased array (16-channel Sense XL Torso).

We used a DW-MRI protocol with 4b-values (b 0, 50, 600, 1000 s/mm$^2$) and the ADC quantification of the APN foci was calculated with monoexponential decay between 50 s/mm$^2$ and 1000 s/mm$^2$. This is fundamental for calculating perfusion-insensitive ADC values, because the degree of perfusion bias in ADC measurement increases with the volume fraction of flow and decreases with the b-value range.

Two observers (S.B. and M.G. with 4-years experience in MR) independently reviewed all images in a double-blinded way.

Qualitative analysis was based on visual assessment of the morphologic T1-weighted images (T1WI), T2-weighted images (T2WI) and DWI (DWI+), as compared with the corresponding ADC map.

For quantitative analysis, the ADC maps were generated (b 50-1000 s/mm$^2$). Oval ROIs were manually drawn as small as possible near the centre of each APN focus for reducing the possibility of signal contamination caused by the partial volume effect. As reference, the ADC of healthy parenchyma was measured by placing freehand-oval regions of interest (ROI) (with diameter of about 1 cm) in the upper, middle, and lower pole of healthy cortical parenchyma.

The largest diameter of each lesion (D) was measured. All lesions were included, regardless of their size.

Continuous variables were expressed as average±standard deviation. Matched variables were compared with Wilcoxon's test (2 variables) or Friedman's test (>2 variables); independent variables were compared with Mann-Whitney's test (2 variables) or Kruskal-Wallis's test (>2 variables). The relation between two sets of data was explored with the eta-squared ($h^2$) coefficient for unordered pairs and Pearson's linear correlation.
The ability of a variable to discriminate between two conditions was assessed by the Receiving Operating Characteristics (ROC) curve.

Dichotomic variables, reported as counts and percentages, were arranged in cross-correlation tables and studied with the chi-square test (with Yates’ correction for 2x2) or Fisher exact test; the risk ratios (RR) were derived with the relative 95% Confidence Interval (CI).

Statistical significance was set at p # 0.05 and RR 95% CI not including 1.

Open source software (www.openepi.com and www.vassarstats.net) and StatPlus: Mac v.6 (AnalysisSoft. Walnut. CA. USA) were used.
Results

At the acute stage, the total number of detected foci was 114. The average maximum dimension was $D_0 = 13 \pm 7.8$ mm. The average ADC$_0$ was $1.3 \pm 0.2 \times 10^{-3}$ mm$^2$/s; the average ratio of the ADC of each focus to the ADC of the relative healthy parenchyma was $R_0 = 0.68 \pm 0.12$. ADC$_0$ and R$_0$ showed a significant inverse correlation with $D_0$: $r = -0.60$, with $p(r=0) < 0.0001$.

At the 1-month FU, at the conclusion of the antibiotic treatment, all patients were free from symptoms and with laboratory values restored to the physiological range: WBC$_1 = 6 \pm 210^9$/L and CPR$_1 = 2.0 \pm 1.5$mg/l; this status was confirmed at the 3 months check-up: no symptoms and stable laboratory values WBC$_3 = 6 \pm 1\times 10^9$/L and CPR$_3 = 1.8 \pm 1.7$mg/l.

In spite of this, at the 1-month examination 39 foci (34%) were still visible (DWI+) with maximum dimension $D_1 = 10 \pm 7$ mm and ADC$_1 = 1.4 \pm 0.2 \times 10^{-3}$ mm$^2$/s ($R_1 = 0.72 \pm 0.11$) and at the 3-months examination 16 (14.1%) persisted visible (DWI+) and had $D_3 = 6 \pm 3$ mm and ADC$_3 = 1.5 \pm 0.2 \times 10^{-3}$ mm$^2$/s ($R_3 = 0.76 \pm 0.10$).

The discriminating ability of ADC$_0$, R$_0$ and D$_0$ was studied with the ROC curve derived from the two distributions relative to the two sets DW- and DW+. Figure 1 shows the level specific Likelihood Ratio (lsLR) derived from the frequency distributions of ADC$_0$ (top panel) and D$_0$ (bottom panel): values of the variables for which lsLR is larger than 1 correspond to the foci with the slowest progression. Table 1 reports for each variable AUC, threshold and associated diagnostic parameters: sensitivity, specificity, positive predictive value, negative predictive value and likelihood ratio of a positive test.

The region characterized by ADC$_0 \geq 1.3 \times 10^3$ mm$^2$/s contains 94% of the DW+ foci versus 48% of the others: $p=0.001$ with RR=2 (95%CI 1.5-2.5). The corresponding region R$_0 \geq 0.7$ contains 69% of the DW+ foci versus 19% of the others: $p=0.0001$ with RR=3.5 (2.1-6). The region D$_0 > 20$mm includes 50% of the DWI+ foci versus 7% of the others: $p=0.0002$ with RR=7 (3-1). The D$_0$ condition is the one with the lowest sensitivity and highest specificity. The region identified by the contemporary existence of ADC$_0 \geq 1.3 \times 10^3$ mm$^2$/s (R$_0 \geq 0.7$) and D$_0 > 20$mm contains 9/16 (50%) of the DWI+ foci and 7/98 (7%) of the others: $p<0.0001$ with RR=8.4 (3.6-19.5).

Figure 3 shows a typical case of achieved *restitution ad integrum* post APN, whereas Figure 4 shows a case with slow radiologic resolution.
Table 1: Parameters relative to the ROC curve procedure based on the features of APN foci at onset (time t0).

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Fig. 1: level specific Likelihood Ratio (lsLR) for ADC0 (Fig.1) and D0 (Fig.2): the region with lsLR>1 corresponds to the foci with the slowest progression toward resolution.

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**Fig. 2:** Level specific Likelihood Ratio (IsLR) for ADC0 (Fig. 1) and D0 (Fig. 2): the region with IsLR > 1 corresponds to the foci with the slowest progression toward resolution.

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**Fig. 3:** A typical case of restitution ad integrum post APN. The top panels refer to the acute DW-MRI (on the left DWI: 1000 s/mm² and on the right the correspondent ADC map) of an APN focus in the right kidney. It appears as an area of high signal on the high-b-value image corresponding to an area of low signal intensity on the ADC map. The middle and bottom panel show the 1- and 3-month follow-up: the APN focus is no longer visible (DWI-).

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**Fig. 4:** A typical case of slow radiologic resolution APN. The top panels refer to the acute DW-MRI (on the left DWI: 1000 s/mm² and on the right the correspondent ADC map) of an APN focus in the left kidney. The middle and bottom panel show the 1- and 3-month follow-up: the APN focus is still visible (DWI+) and its ADC value is lower than the ADC of parenchyma.

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Conclusion

We investigated the evolution of APN foci during a 3-months follow-up as documented by DW-MRI. Our study showed that:

i) At the acute stage the 114 APN foci had average $\text{ADC}_{0}=1.3\pm0.2\times10^{-3}\text{mm}^2/\text{s}$, significantly lower than the ADC of healthy parenchyma $\text{ADC}_{\text{par}}=1.9\pm0.1\times10^{-3}\text{mm}^2/\text{s}$ ($p<0.0001$).

ii) At the 1-month follow-up, when "clinical recovery", defined as the normalization of clinical and laboratory data was diagnosed, the DW-MR presented a more complex and fragmented picture. Only one third of the foci had reached the *restitutio ad integrum* target (DW- and ADC equal to the healthy parenchyma value).

iii) At the 3-months FU the number of visible foci had decreased to 16 (14%) foci: their dimension had shrunk to $D_3=6\pm3\text{mm}$ and their ADC had increased to $1.5\pm0.2\times10^{-3}\text{mm}^2/\text{s}$.

This study has some limitations. First, it covers a limited number of patients, even if with a substantial number of foci. Second, the diagnosis of pyelonephritis was based on the clinical scenario and the radiologic findings without confirmation by histopathology findings. Third, the lack of the contrast media and the dynamic study did not allow us to directly identify complicated APN foci; at the same time, the lack of the contrast media allows a safer use of DWI-MR in all patients.

In summary, our study showed that the "DW-MRI recovery" of APN foci does not necessarily coincide with the "clinical" recovery. $\text{ADC}_{\text{acute}}=1.3\times10^{-3}\text{mm}^2/\text{s}$ ($R_{\text{acute}}=0.7$) and $D_{\text{acute}}=20\text{mm}$ seem to be fairly good predictors of a particularly slow radiologic resolution. The follow up imaging analysis thus requires a careful and thorough exam based on the knowledge of the previous radiological situation for avoiding the risk of a false positive APN diagnosis.
Personal information

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References


