Contrast-enhanced Ultrasound (CEUS) in the Detection and Risk Stratification of Pyelonephritis

Kantonsspital Aarau

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Background

Contrast-enhanced ultrasound (CEUS) has been described as a promising method for detecting acute pyelonephritis and its complications.

The most commonly detected lesion consists of a wedge-shaped (Fig. 1) or rounded (Fig. 2) hypoechoic area, best seen at the late parenchymal phase, more than 60s after contrast injection (Ref. 1).
In some patients small abscesses can be detected showing no enhancement at all (Fig. 3).
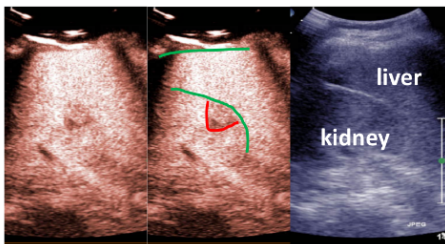

Fig 1. The most typical lesion of pyelonephritis detected by CEUS is a wedge shaped hypoechoic area (marked by red line) best seen at the late parenchymal phase.
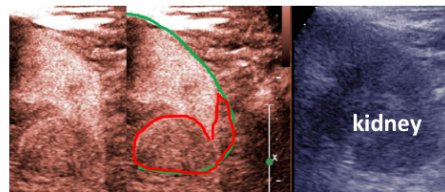

Fig 2. Another example of a pyelonephritic lesion (marked by red line) as seen by CEUS. Note the more rounded appearance.

Objective

Here we evaluated the value of Contrast-enhanced ultrasound (CEUS) in the diagnosis and risk stratification of pyelonephritis in the setting of a randomized controlled trial (RCT).
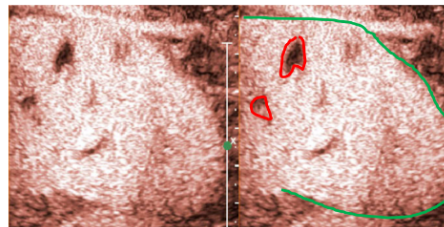

Fig 3. Abscesses (marked by red line) are characterized by anechoic areas through all phases of contrast enhancement.

Materials & Methods

Immunocompetent adults with community-acquired urinary tract infection (UTI) presenting in the emergency department of Kantonsspital Aarau were enrolled in a RCT designed to evaluate the performance of a PCT/ pyuria guided algorithm versus standard guide-lines ("Triple P study", Ref. 2). A flowchart of the trial is shown in Figure 4. Outcomes included antibiotic exposure, duration of therapy, persistent infections and recurrences/rehospitalizations.

In a prespecified substudy, all hospitalized UTI patients with fever and/or flank pain were scheduled to gray-scale, Doppler and Contrast-enhanced ultrasound of both kidneys within 72h after admission, looking for signs of pyelonephritis (PN).
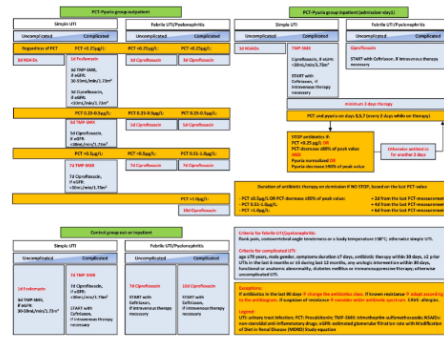

Fig 4. Algorithm for procalcitonin (PCT) and pyuria-guided therapy as used in the TripleP-study (Ref. 2).

Results

Of the 125 randomized UTI patients, 70 were admitted with fever and/or flank pain. 41 (59%) of these underwent study ultrasound. The others did not consent (5), were discharged early (6), or could not be examined due to technical reasons (18).
Examined and non-examined patients did not differ significantly in baseline characteristics (Table 1) or outcomes (Table 2).

Findings suggestive of PN were found in 5/41 (12%).
In 3 patients, this was evident in greyscale/Doppler already, in 2 additional patients, critical findings were only present in CEUS. Thus, the detection rate for findings suggestive of pyelonephritis was almost doubled (12% versus 7%) by adding CEUS to the exam.

The presence or absence of sonographic signs of pyelonephritis was not associated with any specific baseline characteristic or outcome (Table 3).

	examined	non-examined	p-value*
N	41	29	
Demographics			
Age, median (IQR), y	77 (67, 83)	75 (48, 80)	0,24
Female Sex, No. (%)	27 (66%)	19 (66%)	0,98
Charlson comorbidity index, median (IQR)	4 (2, 6)	6 (3, 7)	0,37
Clinical history, No. (%)			
Flank pain	15 (37%)	10 (34%)	0,86
Clinical findings, median (IQR)			
Confusion, No. (%)	14 (34%)	10 (34%)	0,98
Body temperature, °C	38.6 (38.1, 39.2)	38.6 (38.2, 39.0)	0,81
Laboratory findings, median (IQR)			
Serum creatinine, µmol/L	110 (92, 139)	110 (91, 145)	0,92
Blood urea nitrogen, mmol/L	6.9 (5.5, 11)	6.2 (4.8, 12.5)	0,65
Leukocyte count, x 10⁹cells/L	11.7 (8.4, 16.0)	12.9 (9.7, 18.6)	0,30
C-reactive protein, mg/L	60.8 (29, 167)	112 (80.9, 161)	0,19
PCT, µg/L	0.53 (0.18, 2.28)	1.09 (0.27, 4.27)	0,33
ProADM, nmol/L	1.58 (1.25, 2.60)	1.71 (1.21, 2.50)	0,89

*Chi-Square test for categorical variables, 2-sample t test for continuous variables.

Table 1. Baseline Characteristics of Patients selected for CEUS

	examined	non-examined	p-value*
N	41	29	
Median (IQR), days			
Duration of initial antibiotic therapy	9.0 (7.0, 11.0)	9.0 (7.0, 10.0)	0,82
Antibiotic exposure within 90 days	11.0 (7.0, 20.5)	10.0 (7.0, 14.0)	0,28
LOS initial hospitalization	7.0 (5.0, 8.0)	6.0 (4.0, 9.0)	0,75
LOS within 90 days	8.0 (5.0, 10.0)	6.0 (5.0, 11.0)	0,73

*Mann-Whitney U test

Table 2. Antibiotic Therapy Duration and Length of Stay of Patients Selected for CEUS

	Not suggestiv for pyelonephritis (n=36)	Suggestive for pyelonephritis in B-mode and CEUS (n=5)	Odds ratio	95% CI	p-value*
Recurrence within 90 days follow-up	12/36 (33%)	1/4 (25%)	0,67	0.06, 7.11	0,74
Rehospitalization within 90 days follow-up	9/36 (25%)	1/4 (25%)	1,00	0.09, 10.87	1,00
Persistent infection day 7 after end of therapy	3/31 (10%)	0/3			
Persistent infection day 30 after enrollment	6/31 (19%)	0/3			
Death within 90 days follow-up	1/36 (3%)	0/4			

*Linear regression analysis

Table 3. Rates of Adverse Outcomes

Conclusions

Ultrasound evidence of pyelonephritis is rare in patients hospitalized for UTI with fever or flank pain. Adding CEUS to basic greyscale and Doppler ultrasound increases the number of positive findings.

References

1. Fontanilla T et al. Abdom Imaging 2011, 37:639.
2. Drozdov D et al. BMC Medicine 2015, 13:104.

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