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IMAGING METHODS IN THE STUDY OF URINARY TRACT INFECTIONS IN CHILDREN

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SUMMARY

When studying a child with urinary tract infection it is important to detect and localize any renal (scar) or urologic anomaly. Here we study the information obtained using: renal and vesical ultrasound (US), DMSA scan and radiologic or isotopic cystogram. Methods: We studied 148 children with more than one urinary infection and/or pyelonephritis; their mean age was 35.9 months (1-148 months); 55% were girls. The three diagnostic examinations - US, DMSA scan and cistogram were made in this order; the DMSA scan or cystogram was never made sooner than one month after the UTI. Results: In 42% of the children the three exams were normal; 4 of these children had another UTI and the urodynamic study revealed vesical disfunction. 11% had renal scars (DMSA scan) with normal US and cystogram; 30% had VUR, 50% of which had an altered US and 57% had renal scars on the DMSA scan. 12% of the children had an altered US with a cystogram showing no VUR; 66% of these had renal scars. 4% had vesical anomalies in the US and cystogram. Conclusion: The three exams chosen were able to direct the diagnostic approach of UTI, being sufficient in most of the cases. We would like to emphasize the importance of the DMSA scan in diagnosing unsuspected renal scars.

INTRODUCTION

Facing an episode of urinary tract infection (UTI) in a child, three fundamental questions are raised: 1) Is it cystitis or pyelonephritis? 2) Is there a malformation or dysfunction in the urinary system? 3) Is there a renal parenchymatous lesion (scar)?

To answer the first question, clinical and laboratory data are not always sufficiently conclusive [1,2]. As regards the other two questions, the type of combined imaging methods which, used in a smaller number and with a minimum of traumatism for the child, may supply the maximum of useful information are still being discussed. This problem mainly arises when the study of the first UTI is contemplated [2-4]. Even in the case of recurring urinary tract infections (RUTI) however, the methodology applied by various centres is not the same, independently of the similarity of resources [3-6].

Having access to a vast range of complementary methods of imaging and using them in a sequence invariably beginning with renal and vesical ultrasound (US) but diversified according to the results and the data of clinical nature, we wished to analyse the results of the information obtained with the above mentioned means, particularly the DMSA (dimercaptosuccinic acid) scan and the radiologic or isotopic cystogram.

We thus seek to assess if the methodology we employed would prove adequate, or on the contrary, insufficient or excessive.

METHODS

Our population consisted of 148 children, 82 female and 66 male. Their ages were between 1 and 148 months with an average age of 35.9 months; 53 children were infants (36%), 67 were between the ages of 1 and 5 years (45%) and 30 children were older than 5 years (19%).

The average age at the first UTI was 27.1 months, varying between 1 and 108 months.

Of these children, 86 were seen for recurring low urinary tract infections (LUTI) and 60 for a first occurrence of acute pyelonephritis (APN).

The diagnosis of UTI was based on a uroculture performed at our hospital or at a recognized laboratory [1]. The diagnosis of APN was made in situations in which apart from a series of urinary complaints with positive

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uroculture, there were clinical/laboratory signs of systemic involvement - fever, vomiting, abdominal pain, prostration, leucocytosis with neutrophilia and positive PCR [2].

The first examination performed was usually the renal and vesical US; the cystogram was not performed during the period of infection and the renal DMSA scan was performed at least 4 weeks after the episode of UTI.

RESULTS

The result as a whole of the three referred examinations - renal and vesical US, renal DMSA scan and radiologic or isotopic cystogram, allows us to classify the patients in several groups which we will now describe *(Figs. 1,2)*.

a) Normal US + Normal radiologic or isotopic cystogram + Normal DMSA scan (without renal or urologic pathology).

This group was composed of 62 children (42% total) with an average age of 25 months (varying between 1 and 120 m) *(Fig.3)*; 27 children were infants (43%), 30 were between 1 and 5 years of age (48%) and 6 were above 5 years of age (9%). Sex distribution was the same.

The patients were characterised by LUTI in 23 children (58%) and first occurrence of APN in 26 cases (42%) *(Fig.3)*.

This group was kept under surveillance for at least 12 months, when urinary habits, flow, preputial adherence, lack of hygiene, intestinal parasitoses or chronic obstipation were detected and corrected. At the end of this period, 4 children had UTI again and presented urinary pattern alterations; the three already mentioned examinations were normal once again: therefore a urodynamic study (UDS) was performed which was abnormal in the 4 children, (vesico-sphincteric dissynergism).

b) Normal US + altered DMSA scan (renal scar without evidence of urologic pathology).

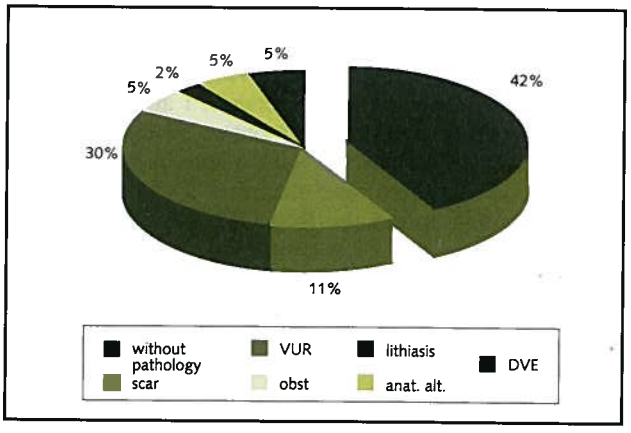

Fig. 1 – Diagnostic groups

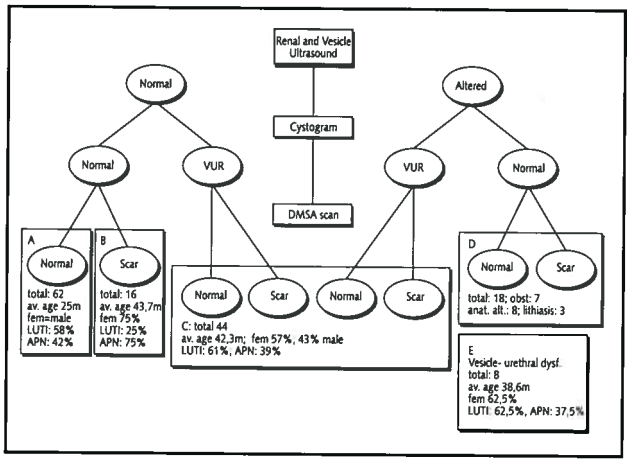

Fig. 2 – Approach and diagnostic groups

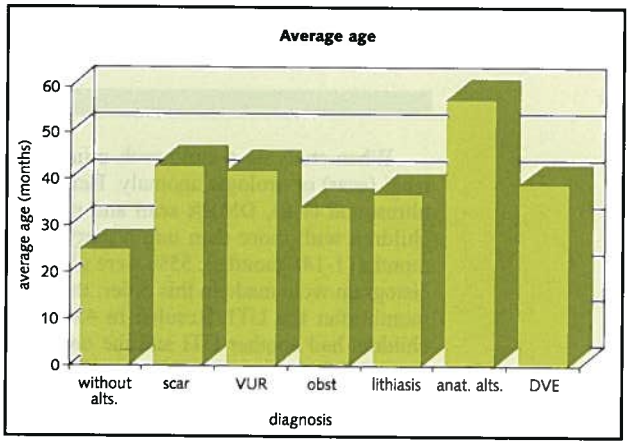

Fig. 3 – Average age

This group consisted of 16 children (11%) with an average age of 43.7 months between 1 and 118m *(Fig. 3)*; predominance of females - 75%, with a majority of children with a history of APN - 75%; 25% of these children with renal scars did not have a history of high UTI *(Fig. 4)*.

After a 12 month follow up only one child of 48 months had a UTI; the repetition of the above mentioned studies and a urodynamic study did not reveal other anomalies.

To assess the evolution of the renal compromise, these children are summoned once again 5 years after the detection of the renal scar.

c) Abnormal cystogram (Vesico - ureteric - reflux). This group consisted of 44 children (30%) with an average age of 42.3 months varying between 2 and 120 months (Fig. 3); 25 children were female (57%) and 19 male (43%); 27 children were LUTI patients (61%) and 17 were APN patients (39%) *(Fig. 4)*.

An isotopic cystogram was performed on 18 children, a radiologic cystogram on 15 children and 12 children were submitted to both examinations. Only in one case did the two examinations disagree, with bilateral VUR,

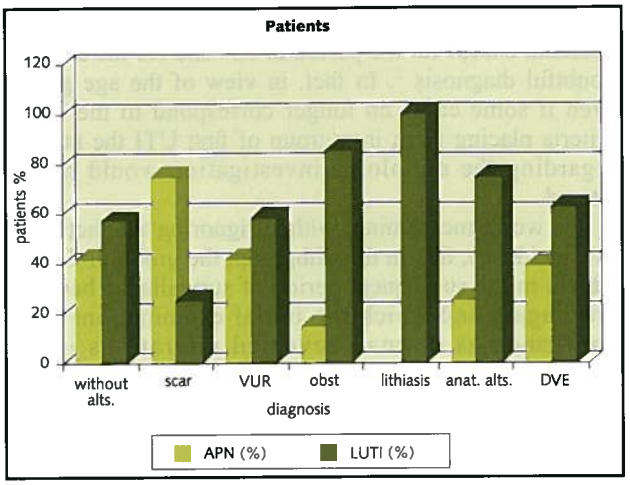

Fig. 4 – Clinical Presentation

2nd degree in the radiologic cystogram and an isotopic examination interpreted as normal.

In these 44 children the renal and vesical US was normal in 22; in 6 children it detected anatomical anomalies associated to the UVR: pyelitic - duplication (3 cases), single kidney (2 cases), uretherocele (1 case); in 15 cases the suspected diagnosis of RVU was reached due to the detection of slight pyelocalyceal ectasias, confirmed by cystogram (UVR degree>=2).

The DMSA scan showed the existence of renal scarring associated to UVR in 25 cases (57%). The DMSA scan was different in 5 of the 10 infants (50%), in 14 of the 20 children aged between 2 and 5 years (70%) and in 7 of the 8 children above the age of 5 (87%).

d)Normal US with cystogram without reflux.

The renal US diagnosed the basic pathology in 18 children. Seven of these children had obstructions, 8 had anatomical alterations without reflux or obstruction and 3 had renal lithiasis.

The group of children with an obstruction was of an average age of 33,8 months between 2 and 104 m; 4 of the children were male (57%) and 3 were female (43%) (Fig. 3); 6 of the children had a history of LUTI (86%) and 1 of APN *(Fig. 4)*.

This group was submitted to an intravenous urogram (IVU) which confirmed the US diagnosis. The renogram with DTPA and examination with furosemide suggested mechanical obstructions in 6 children and functional obstruction in one child with left pyelo-ureteric obstruction. The mechanical causes of obstruction were ureteric stenoses in 4 children, (in one child related with lithiasis) urethroceles in two.

The renal DMSA scan was altered in all the children with mechanical obstruction (86%) but normal in the child with a functional obstruction (14%).

In the group of 8 children with isolated anatomical abnormalities the average age was 57.6 months (10 to 108 m) (Fig. 3) the highest incidence being in females: 6 girls (75%) and 2 boys (25%); of these, 6 had a history of LUTI (75%) and 2 a history of APN (25%) (Fig. 4).

This group was submitted to IVU which confirmed and provided details for the US diagnosis: right duplications in 5 children, bifid renal pelvis in one child and single kidney in two.

The DMSA scan was normal in 3 of the children with duplication (37.5%), being altered in the other 5 children (62.5%).

In the group of 3 children in which the US diagnosed urinary lithiasis the average age was 48 months (24, 36, 84 m) (Fig. 4), two were males (66%) and one female; all three had a clinical presentation of LUTI (Fig. 5). Apart from the DMSA scan and the cystogram (which were normal) they were submitted to a selective urogram which confirmed the diagnosis of lithiasis and denied the existence of an associated obstruction.

e)Renal - Vesicle US and radiologic cystogram suggesting vesico - sphincteric dysfunction.

The detection of a bladder of large proportions or of thick walls without other associated alterations by renal - vesicle US and radiologic cystogram raised the suspicion of renal dysfunction; a urodynamic study which diagnosed vesico - sphincteric dysfunction was made on these children. In this group the renal DMSA scan was altered in 4.

The ages of this group varied between 24 and 60 months with an average of 38.6 months (Fig. 4)); 5 children were female (62.5%) and three male (37.5%); 5 had a clinical history of LUTI (62.5%) and 3 of APN (37.5%) *(Fig. 4)*.

DISCUSSION

The combination of IVU and cystogram, for the study of the urinary system of the child with UTI, despite being quite informative, does not reply to all the questions raised by the situation which might be unnecessarily aggressive in terms of irradiation [6,7,8]. Thus, alternatives have been sought which have to include the renal and vesicle US and associate various isotopic methods, relegating IVU to second place, without being dispensed with in well selected cases [3,4,5,6].

Despite the innocuity of US allowing the widening of the spectrum of children with UTI in which imaging studies are performed [9,10], the use of the remaining methods in order to obtain the maximum amount of information with the minimum acts of irradiation is still contemplated.

In this perspective, the scheduling of the examinations should first of all be conditioned by the symptomatology and the examination, but also by the age of the patient and the fact that it is the first UTI or RUTI. Therefore the child with RUTI should be studied with all the means which are thought necessary. In what concerns the first UTI, there are centres in which research on any age group, whatever the sex of the child may be, is made as if it were RUTI, however there are other centres, among

which we are included, which exclude a systematic approach in the case of a first UTI in a female child of more than 5 years of age, as long as there is no indication of APN. This attitude is based on the higher incidence of UTI in females and the low probability of a child above 5 years of age having a urologic malformation without a previous UTI. Naturally, this attitude follows a detailed history and does not dispense later surveillance.

In the approach of the radiologic study of the first UTI in children above 5 years of age there are different attitudes; namely centres which include US, cystogram and DMSA scan in their first series and others which dispense the cystogram as long as the DMSA scan does not reveal any scars [4,5]. The attitude of the latter is based on the rarity of new scars appearing after this age, therefore admitting that even though an existing VUR is not diagnosed there will not be future problems for the child in question [2]. The protocol followed in our department is according to the first approach because we do not consider rarity the same as inexistence and if the second approach is logical from a statistical point of view, it may not satisfy the needs of the patient in question from an individual stand point. For this patient the plain fact of having a pathology capable of causing new UTI and eventually a renal lesion makes it necessary to diagnose it or exclude it [3-6,12]. Based on these general principles, our radiologic research begins with renal and vesicle US. Only in the cases in which this US along with clinical data dispenses a cystogram and another sequence is advisable, is this US made and a DMSA scan.

On assessing the study group globally, we may verify that the average age of the children was low: average of 35.9 m and 80% below 5 years of age, which will certainly influence the relationship of 1,2:1 found between females and males, lower than that described when considering the age group until 15 years [7,6,13].

The incidence of urologic alterations was of 80% in the age group above 5 years of age and of 57% and 60% respectively in the group of infants and of 1 to 5 years of age. While the first figure corresponds to what is expected in a group of patients with RUTI after 5 years of age, the incidence of 57% found in the first year period is closer to what is usually accepted for patients with a first UTI. This fact raises a suspicion of the credibility of some previous episodes of infection in an age group in which the diagnosis of UTI may easily not be true [14].

The same comments can be made on the first subgroup formed, that is, the group of 42% of children without any alteration - in the US, DMSA scan or cystogram. This is the subgroup with the lowest average age - 25m - with 91% of the cases below 5 years of age. In this group there is a clinical and laboratory suggestion of acute pyelonephritis in 42% of the patients, with the DMSA scan not revealing any scar [12]. Thus it should be admitted that some cases classified as RUTI or as APN were not really so.

Those who defend the systematic supra-pubic puncture in infants will have an argument here in favour of their approach [15]. However we still do not defend this position, except for the period of RN and for the cases of doubtful diagnosis [2]. In fact, in view of the age group, even if some cases no longer correspond to the RUTI criteria placing them in a group of first UTI the attitude regarding the radiologic investigation would not be altered.

It is worth mentioning, without ignoring the fact of its low incidence, that in this subgroup, the group of 4 cases which, in the subsequent period of surveillance had UTI once again and which the initial examinations were confirmed as normal, revealed alterations in the urodynamic study. Despite the low probability that this situation may become harmful to the kidney, in view of the absence of VUR, such would not be impossible and its diagnosis made it possible to understand the reason for the recurring episodes of UTI and allowed its eradication.

The second subgroup, characterized by the existence of scars in the DMSA scan, despite the inexistence of US or cystogram alterations represented 11% of the population studied. It consisted of a group of children with an average age above that of the previous subgroup and already showing an evident predominance of females.

This subgroup raises a question of the causes of their renal scars, which in the current phase of our knowledge, may be attributed to the existence of APN by E. coli with the capacity of adhering to the uroepithelium, to the previous existence of VUR, disappeared at the time of investigation or yet to the possibility of intermittent VUR [2]. In this group only one child had another episode of UTI and a review of the situation did not reveal any alteration in the initial data; the urodynamic study of this child did not reveal any alterations either.

Another aspect to be pointed out in this subgroup is the existence of a clinical suspicion of APN in 75% but the inexistence of that suspicion in 25% who revealed scars. If a DMSA scan is mandatory in the cases of suspected APN, despite the eventuality of an absence of scars already shown, only the systematic inclusion of this examination in the study protocols of these situations may detect lesions which were not suggested clinically [14]. Despite the probability of new scars being low above 5 years of age and their probability lowering even more in the absence of VUR, their diagnosis obliges us to observe these children over a longer period, thus contributing to a better understanding of their natural history and in some cases a possible early alteration and treatment of high blood pressure [12].

The third subgroup, characterized by the existence of VUR, consists of a population with a similar average age to the previous group and showed a female/male relationship without a great predominance of the former. It is worthwhile pointing out the fact that the US was normal in 50% of the cases, which had VUR (degree <2). In the remaining cases, the US showed slight pyelic dilatations corresponding to VUR (degree <2) or revealed associated alterations such as pyelic duplication or single kidney. These data support the attitude that a cystogram should not be excluded in view of a normal

US and the notion that the existence of moderate pyelic dilatations in the US not associated to obstruction may give rise to VUR greater than 2nd degree.

In what concerns scar lesions, although the clinical suspicion of APN was verified in 41% of the children of this subgroup, the DMSA scan showed scars in 57%. It is important to consider that the distribution of its incidence by age groups was of 50% in infants, 70% in the group from 1 to 5 years of age and 87% in the children above 5 years of age. These data are clearly demonstrative of the absolute need to diagnose the RVU situations very early [2]. The eventual excess of investigation which may take place in the first years of life as a consequence of the over valorization of clinical elements is certainly compensated by the possibility of prevention of lesions in children which have anatomical and functional conditions to develop them.

The fourth subgroup considered, which we characterize by normal US and cystogram without VUR, is obviously heterogenous. Upon studying it one may fundamentally draw the notion of the importance of renal and vesical US for diagnosis, the remaining examinations functioning as satellites which should be planned with specific objectives and not as part of an inflexible protocol.

Thus, in all the obstructive situations (high and low) ultrasound revealed the correct diagnosis in 6 out of 7 and revealed a unilateral hydronephrosis which the renogram with furosemide came to suggest as functional. In situations of isolated anomalies such as bifid renal pelvis, single kidney and lithiasis the main diagnosis was also suggested by US allowing the cystogram to exclude the existence of VUR and the DMSA scan to determine which of these patients had renal scars. It should be noted that renal scars were found in 11 children (61%) when only 3 (16,6%) had suggestive elements of APN.

The last subgroup considered was characterized by a large bladder and thick walls shown by the US and by the cystogram without any other alterations of the urinary tract. The understanding of the presentation of the bladder and of the RUTI of this group was supplied by a urodynamic study which revealed vesicle and sphincter dissinergisms in children with a completely normal neurologic examination. A carefully recorded history, however, allowed the detection of suggestive elements of vesical dysfunction.

Despite the relatively small number of these cases it is indispensable to be attentive to its existence. In fact, even without VUR, at least visible at the time of diagnosis, or obstruction with repercussions on imaging regarding the bladder, they may be the object of renal scar lesions as was verified in 50% of the respective group.

Of the overall and seriate analysis of this group of patients it can be verified that:

1. The renal and vesical US as the first complementary imaging examination allowed the immediate selection of 32.5% of cases with alterations and furnished all with a diagnosis which only needed to be verified and complemented for further information by the remaining methods. In the remaining 67.5% of patients it allowed the exclusion of the possibility of obstruction and minimise the probability of diagnosing VUR of a degree above 2.

2. The DMSA scan showed a total of 56 cases (37.8%) with renal scars in this population. However, if we exclude the group of 62 children without any imaging alterations we see the number of cases in which the scars are associated to various alterations of the urinary system increase to 45.9%. On the other hand it proved to be a particularly useful examination in revealing lesions in patients without a clinical suggestion of APN and in verifying the inexistence of renal scars in children with suspected APN.

3. The cystogram was an indispensable examination for the full understanding of all the cases allowing a complete documentation of the normal urinary tract of 62 children. Without it, this statement could not be made. Its eventual utility or uselessness in the cases of first UTI in children with more than 5 years of age and with a normal DMSA scan could not be inferred in this study.

With the methodology followed, the IVU was limited to 12% of cases, thus lowering the corresponding irradiation. The urodynamic study arose as a 3rd stage examination indispensable for the full understanding of 12 cases, 4 of which did not have any evidence from imaging of urinary tract pathology. The renogram with DTPA, despite being referred in this paper only for the differential diagnosis between functional and organic obstruction of hydronephrosis, is an examination of enormous value for the characterization of the individual function of each kidney and for the study of the elimination curves. Having its own indications, it was not indicated in this paper intentionally as it does not correspond to its objectives.

We are able to conclude that the systematic association of renal and vesicle US, of DMSA scan and radiologic or isotopic cystogram performed in precisely this order allows a quite complete and reliable answer to the questions raised in the introduction of this paper. However, a study of the clinical elements and the information provided by US should always be made in order to confirm the need for a cystogram and to consider the usefulness of other examinations.

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