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Computed Tomography and Ultrasound of Renal and Perirenal Diseases in Infants and Children

Relationship to Excretory Urography in Renal Cystic Disease, Trauma and Neoplasm

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Abstract. Forty-seven infants and children had excretory urography, ultrasound, and computed tomography with the renal and perirenal areas as the primary regions of interest. Ultrasound is an excellent screening procedure and is often diagnostic especially in renal cystic disease. Computed tomography best demonstrated the extent of renal injury and best delineated the geography, character, and extent of solid renal and perirenal neoplasms (screened by ultrasound). Excretory urography in these patients was at times incorrect, often underestimated the extent of the pathologic process, and is often unnecessary.

Key words: Computed tomography – Ultrasound – Kidneys – Retroperitoneum

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We have performed 350 body computed tomograms and ultrasound examinations in infants and children and in 47 patients the renal and perirenal areas were the primary region of interest. We wish to report our experience in three disease categories: cystic disease, renal trauma, and renal and perirenal neoplasms, and discuss the present relationship of these imaging modalities to the excretory urogram.

Techniques

Excretory urography was performed utilizing 30-second, 5-minute supine, and 10-minute prone films as a standard, with additional views and tomography obtained as clinically indicated. Ultrasound examinations were performed on a Unirad Greatone III. Computed tomography was initially performed on an Ohio Nuclear Delta 50 scanner, but the majority of patients were examined on an Ohio Nuclear 2010 scanner using a scan time of two seconds. Most patients were given intravenous contrast material administered as a bolus in a dosage of 2–3 cc/kg, up to a maximum of 100 cc.

Results

Renal Cystic Disease

In evaluation of possible cystic disease, ultrasound is the initial procedure of choice (Table 1). We have found as have others [6, 8, 10] that children or anyone with polycystic kidney disease may have normal excretory urography and nephrotomography when ultrasound and CT will demonstrate intrarenal cysts. The excretory urogram was interpreted as normal in four of 14 patients who were demonstrated by ultrasound to have renal cysts. These were in children with small cysts of the kidney studied as part of a familial evaluation. In only one of the 14 patients studied was the excretory urogram of significant value and this only to confirm an ultrasound diagnosis of renal tubular ectasia [11]. CT scanning may dramatically demonstrate the renal abnormality (Fig. 1A, C), however, the correct diagnosis can almost always be made with ultrasound (Fig. 1B, D). CT may be of value when the ultrasound examination is equivocal. In children with tuberous sclerosis excretory urography may show evidence of polycystic disease, angiomyolipomata, or a combination of both. The diagnosis can be made by ultrasound [6], but can be directly demonstrated with CT which can measure the differing tissue densities and definitively identify lipomatous tissue (Fig. 2A, B) [4].

Renal Trauma

We have examined seven children with suspected serious renal injury and have found that CT offers

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Table 1. Ultrasound and CT findings in 14 infants and children with renal cystic disease

Diagnosis	No. patients	Ultrasound	CT
Infantile polycystic	1	Large kidneys, markedly echogenic diffusely	Dense enhancement of enlarged kidneys due to iodide in dilated collecting tubules
Multicystic	2	Unilateral, multiple cysts of varying sizes with echogenic stroma	Non-functioning renal mass with multiple fluid filled cysts
Polycystic and angiomyolipoma	2	Areas of cystic sonolucency with areas of intense echogenicity	Large kidneys with cystic and solid regions; definite fatty tumors, with some enhancing regions
Adult polycystic	7	Slightly large kidney, with multiple small areas of sonolucency	Slightly large kidneys with multiple small cysts within normal appearing renal parenchyma
Renal tubular ectasia	2	Large kidneys, distorted pelvocaliceal pattern and increased echogenicity	Focal areas of low density solid tissue following contrast enhancement in large kidneys

Table 2. Renal trauma (7 patients)

	HX	IVP	CT	U/S
1. N. F.	Post bx pain	Normal	Intra, peri and para renal hematoma	
2. J. B.	Post bx pain	Contusion	Intra and perirenal hematoma	Perirenal hematoma
3. D. N.	Trauma	Contusion	Perirenal hematoma and extravasation	
4. D. T.	Trauma	Normal	Progressive perirenal hematoma	Progressive perirenal hematoma
5. W. S.	Trauma	Hematoma lower pole	Laceration with perirenal hematoma L4-diaphragm	
6. A. B.	Trauma	Hematoma upper pole	Lacerated kidney large perirenal hematoma	Large perirenal hematoma
7. A. S.	Trauma	Normal	Kidney normal splenic hematoma	Normal kidney

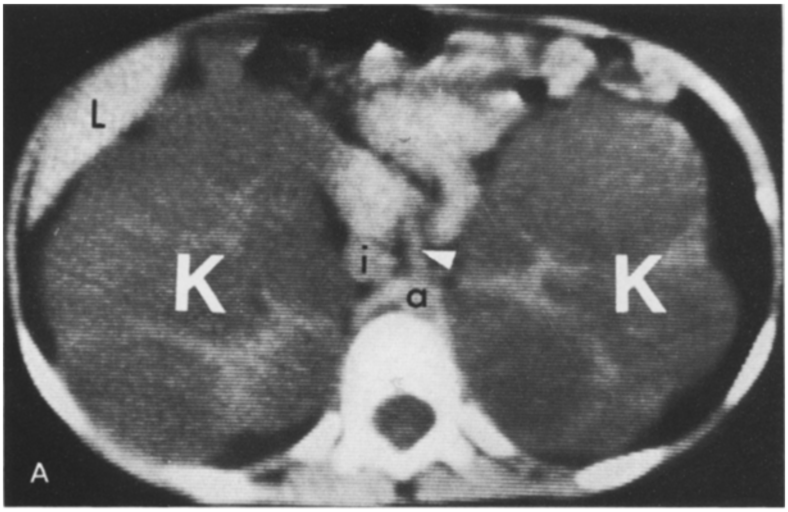
Table 3. Renal and perirenal neoplasms

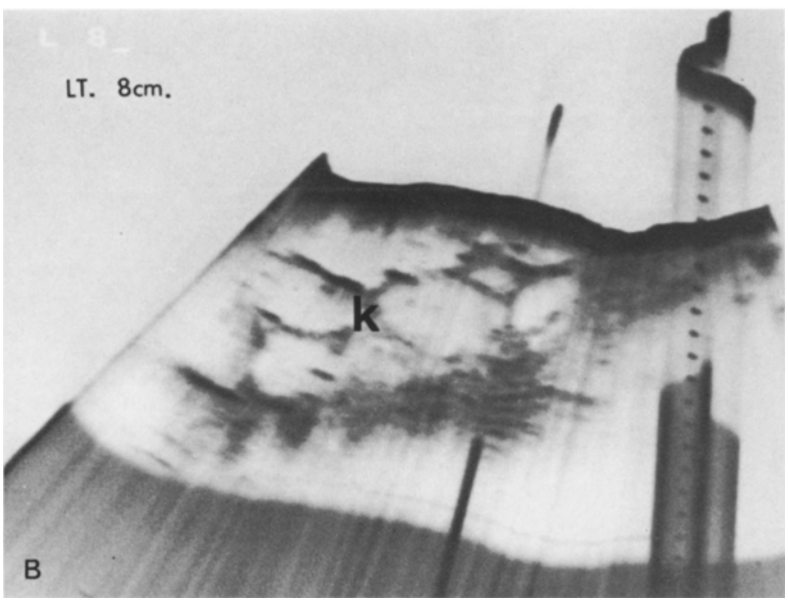
Wilms'	5
Neuroblastoma	17
Angiomyolipoma	2
Renal lymphoma	2

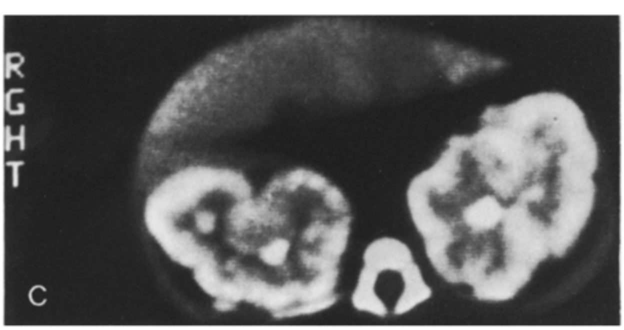
significant advantages over excretory urography and ultrasound (Table 2). We have found that CT is superior to excretory urography in these patients by much more accurately demonstrating the extent of renal injury which was usually significantly underestimated on excretory urography (Fig. 3). Computed tomography has an advantage over ultrasound in that it demonstrates both anatomy and function. In the four patients examined by both ultrasound and CT we found that although the perirenal abnormalities were demonstrated well by both modalities, CT more clearly delineated the intrarenal pathology, specifically, renal laceration and intrarenal hematoma. CT also allowed simultaneous evaluation of other body viscera as demonstrated in Case No. 7 wherein unsuspected splenic hematoma was diagnosed. The only patient who required surgery in the series had persistent flank pain and progressive increase in size of a perirenal hematoma on serial CT examinations two weeks apart. In this patient although the initial CT showed a subcapsular hematoma, the excretory urogram was interpreted as normal.

Renal and Perirenal Tumors

Twenty-six children with renal and perirenal neoplasms comprised the largest group of patients studied in this series (Table 3). We found that the correct diagnosis can usually be established by excretory urography and ultrasound. However, we found that the extent of disease at the time of diagnosis was best delineated utilizing computed tomography. The rapid scan time when combined with a bolus injection of intravenous contrast material







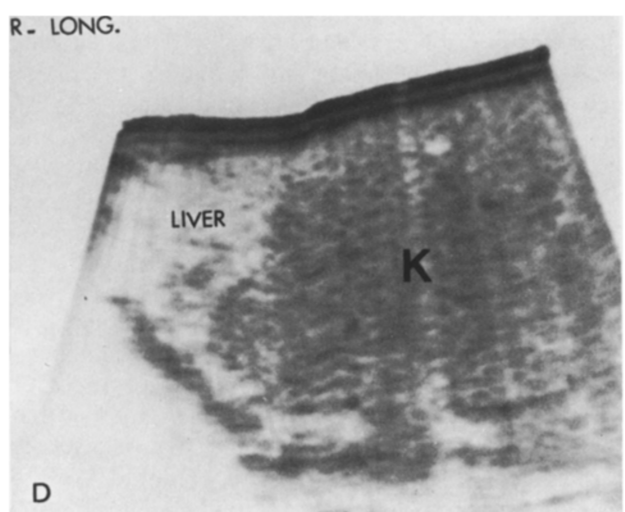


Fig. 1. A CT scan without intravenous contrast on a 4-year-old with very large bilateral polycystic kidneys (a = aorta, i = inferior vena cava, arrowhead = superior mesenteric artery, k = kidneys, l = liver). **B** U/S of same patient as in (A), longitudinal plane, demonstrating polycystic kidney. **C** CT on 2-day-old baby demonstrating severe infantile polycystic kidneys bilaterally. There is dense enhancement of enlarged kidneys due to iodide in numerous dilated collecting tubules. Excretory urogram at this time did not show the kidneys but follow-up films at 24 and 48 hours showed classical infantile polycystic kidneys. **D** U/S on same baby as (C) with densely echogenic right kidney due to echoes from numerous small dilated collecting tubules

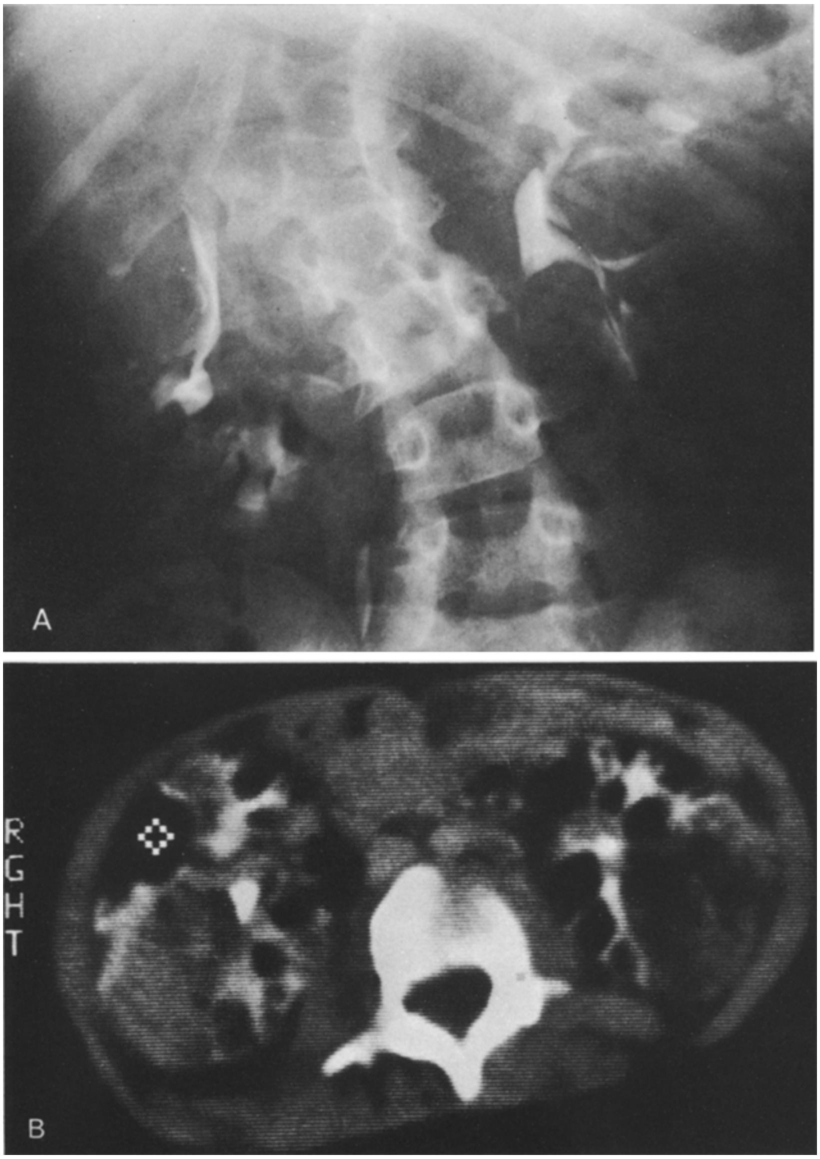


Fig. 2. A 16-year-old girl with tuberous sclerosis, large kidneys with distorted calyceal collecting system. Differential diagnosis: polycystic kidney vs angiomyolipomata. **B** CT demonstrating swiss cheese appearance of kidneys with measuring cursor reading of −87 Hounsfield units diagnostic of lipomata. Diagnosis: bilateral angiomyolipomas. CT also revealed multiple cysts within the liver

(3 cc/kg) permits excellent anatomic detail showing relationships of the abdominal tumor to the major vessels and clearly delineates tumor extent (Fig. 4). We have found this to be superior to ultrasound and far more informative than excretory urography.

Discussion

The excretory urogram traditionally has been the first imaging procedure performed when renal, perirenal, or retroperitoneal pathology is suspected. Our experience with ultrasound and CT has taught us that this should not always be the rule. We believe the radiologic evaluation should be tailored to the patient's suspected clinical problem.

Ultrasound, because of the lack of ionizing radiation and the anatomic detail now attainable [3] is an

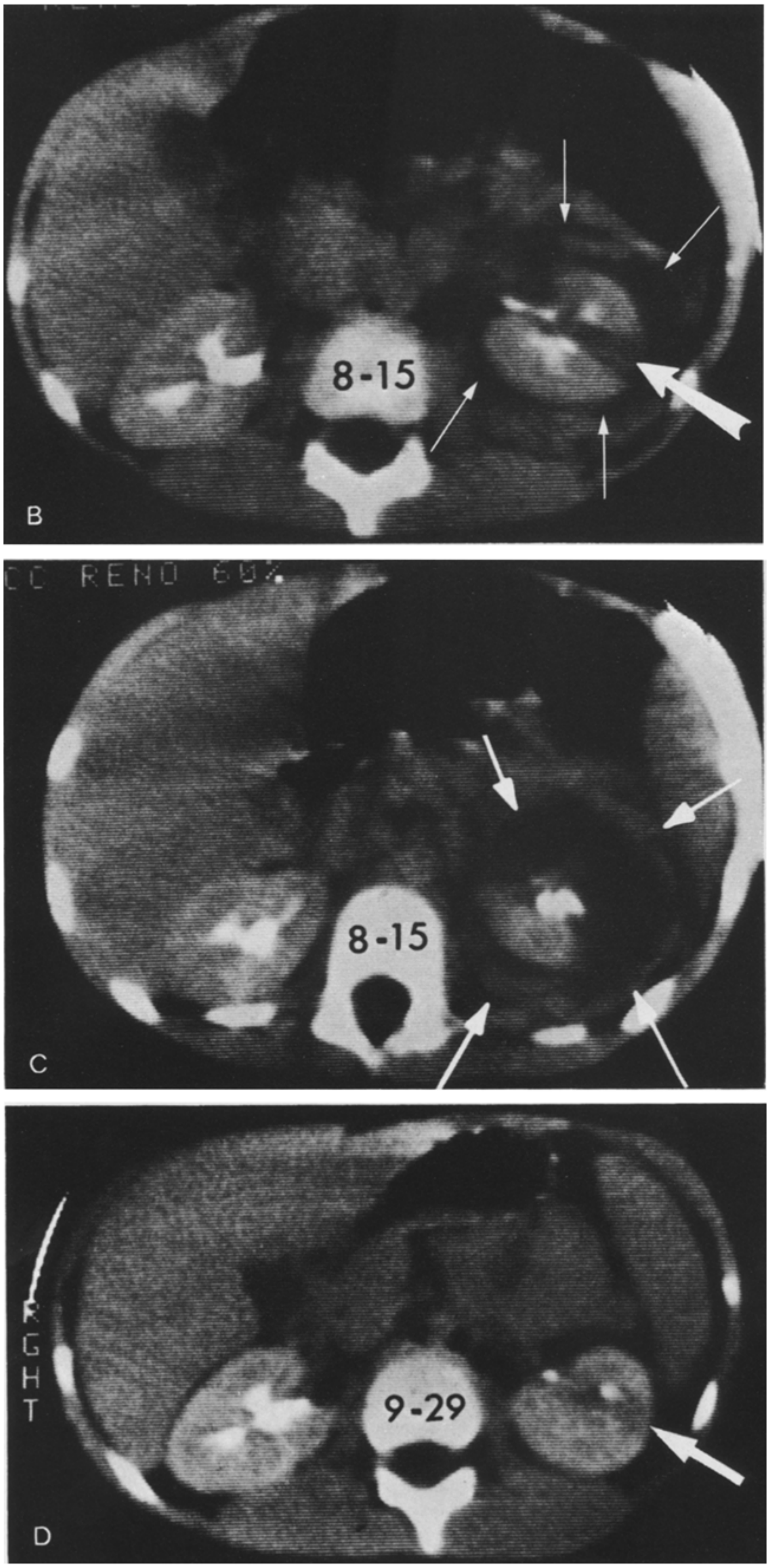


Fig. 3. A 8-year-old boy fell off bicycle and developed left flank pain and hematuria; excretory urogram interpreted as left upper pole contusion. **B** CT of level just above renal hilus demonstrates laceration (large arrow) and perirenal hematoma (small arrows). **C** CT at upper pole demonstrates severe renal tear and large hematoma (arrows). **D** CT scan at six week follow-up showing healing of the laceration (arrow) and complete resolution of the perirenal hematoma

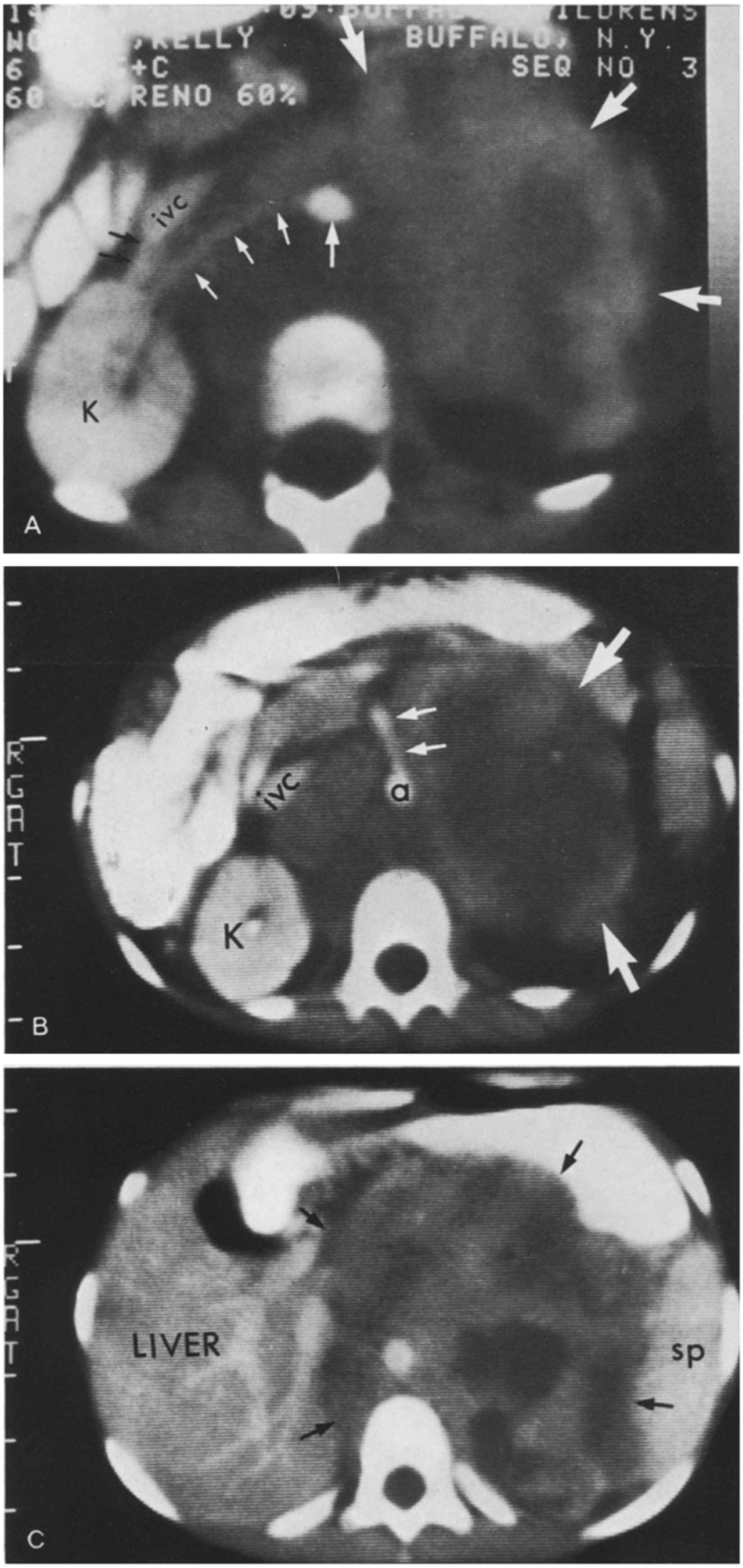


Fig. 4 A–C. 4-year-old girl had IVP showing large faintly calcified left upper quadrant mass displacing kidney inferiorly. CT scan demonstrated the precise character and geography of the tumor, encasing major vessels, and demonstrating non-resectability. **A** Mass (large white arrows) completely encases aorta and right renal artery (small white arrows) and displaces right renal vein (black arrows) and inferior vena cava (IVC) to the right. Lower section demonstrated tumor encasement of left renal artery. **B** CT at level of superior mesenteric artery (small white arrows) demonstrates encasement of this vessel and aorta (a) by tumor (large white arrows). **C** Tumor extends into lesser sac displacing gastrografin filled stomach anteriorly and into region of porta hepatis but there are no hepatic metastases (sp = spleen). Note portal and hepatic veins. Diagnosis: neuroblastoma

excellent screening modality for many suspected problems. Ultrasound may often be diagnostic and be the only imaging examination necessary [13]. We have found this to be the case with suspected renal cystic disease in infants and children and recommend it as the initial procedure of choice. The excretory urogram may be inaccurate as was the case in four of our 14 patients, and is often unnecessary.

Computed tomography of the kidney and retroperitoneum has several advantages and disadvantages when compared with ultrasound and excretory urography [5, 12]. CT equipment is expensive and uses ionizing radiation. However, CT is less operator dependent than ultrasound. CT demonstrates renal function as compared to ultrasound but is not as dependent on renal function when comparison is made with excretory urography. Its abilities to provide superior anatomic detail and measure tissue densities are advantages over both ultrasound and excretory urography.

Today, most renal trauma is treated conservatively. However, in a child with suspected serious renal trauma (severe flank pain, or hematuria, and flank pain) who does not require immediate surgery, CT by providing superior anatomic detail offers significant advantages over excretory urography and ultrasound. It might be argued that since these patients are usually treated conservatively, the excretory urogram will suffice. However, we feel that if any examination need be done, it is CT which best defines the extent of injury and provides an easy modality for accurate follow-up (Fig. 3). In addition, accurately knowing extent of injury may result in more appropriate conservative management resulting in a shorter hospital stay and earlier return to activity.

In children with suspected renal and perirenal tumors, although the correct diagnosis can usually be established with excretory urography and ultrasound, we are now placing a greater emphasis on delineating the entire extent of pathology prior to surgery or biopsy. The extent of disease at the time of diagnosis is perhaps the most important factor in long-term prognosis of a child. In a previous publication on the value of CT and ultrasound in a study of children with neuroblastoma, we stated that CT and ultrasound were complementary modalities [1]. At that time we were using a CT scanner with a scan time of 2:20. For the past year, however, we have up-dated our CT equipment to a scanner with a scan time of two seconds per image (Ohio Nuclear Delta 2010). We have found use of the rapid scan time and bolus injection of intravenous contrast material to provide superior anatomic detail and allows a better delineation of extent of disease when compared with ultrasound, and is far more informative than excretory urography.

In a child with an abdominal mass, we start with plain films of the abdomen and proceed to ultrasonography. If the mass is cystic or hydronephrotic, the ultrasound examination will usually define and delineate the pathologic process, and CT is not usually necessary. With a solid abdominal tumor, our experience has been that CT will best define the geography and character of the tumor prior to surgery and aid in planning the subsequent chemotherapy and radiation therapy when necessary (Fig. 5). In patients in whom the suspected pathologic diagnosis is Wilms' tumor, we will perform a CT scan of the lungs at the same time, as we have found as others have reported, that this is superior to conventional tomography in detecting pulmonary nodules [9, 15]. In children with solid

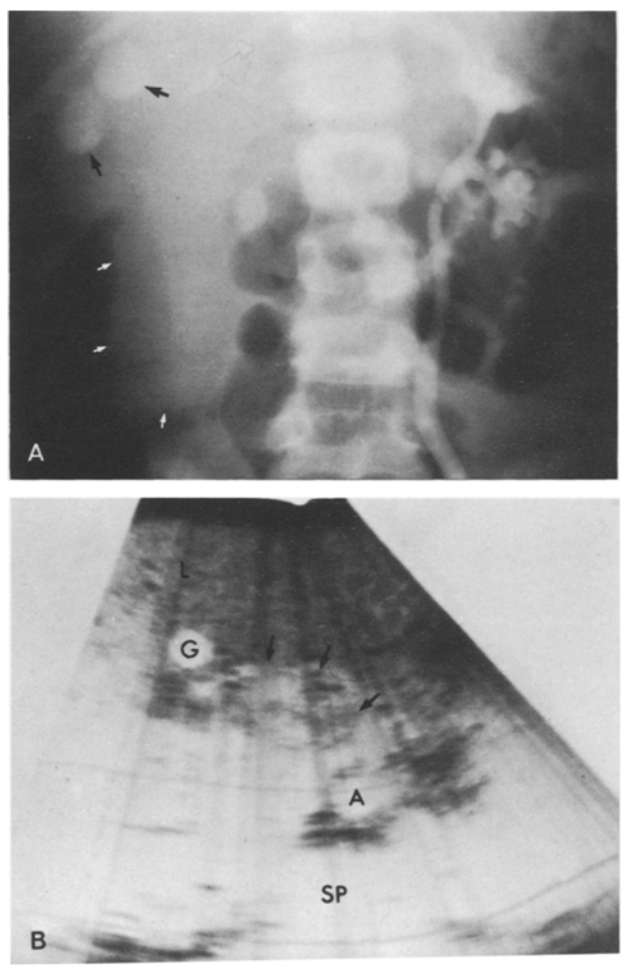


Fig. 5 A–E. A 8-year-old girl with right-sided mass. Excretory urogram demonstrated the mass (small arrows) and calyceal distortion (large arrows) thought to be a Wilms' tumor. **B** Transverse U/S demonstrates echogenic mass (arrows) crossing the midline. Inferior vena cava could not be well delineated (sp = spine, A = aorta, G = gall bladder, L = liver)

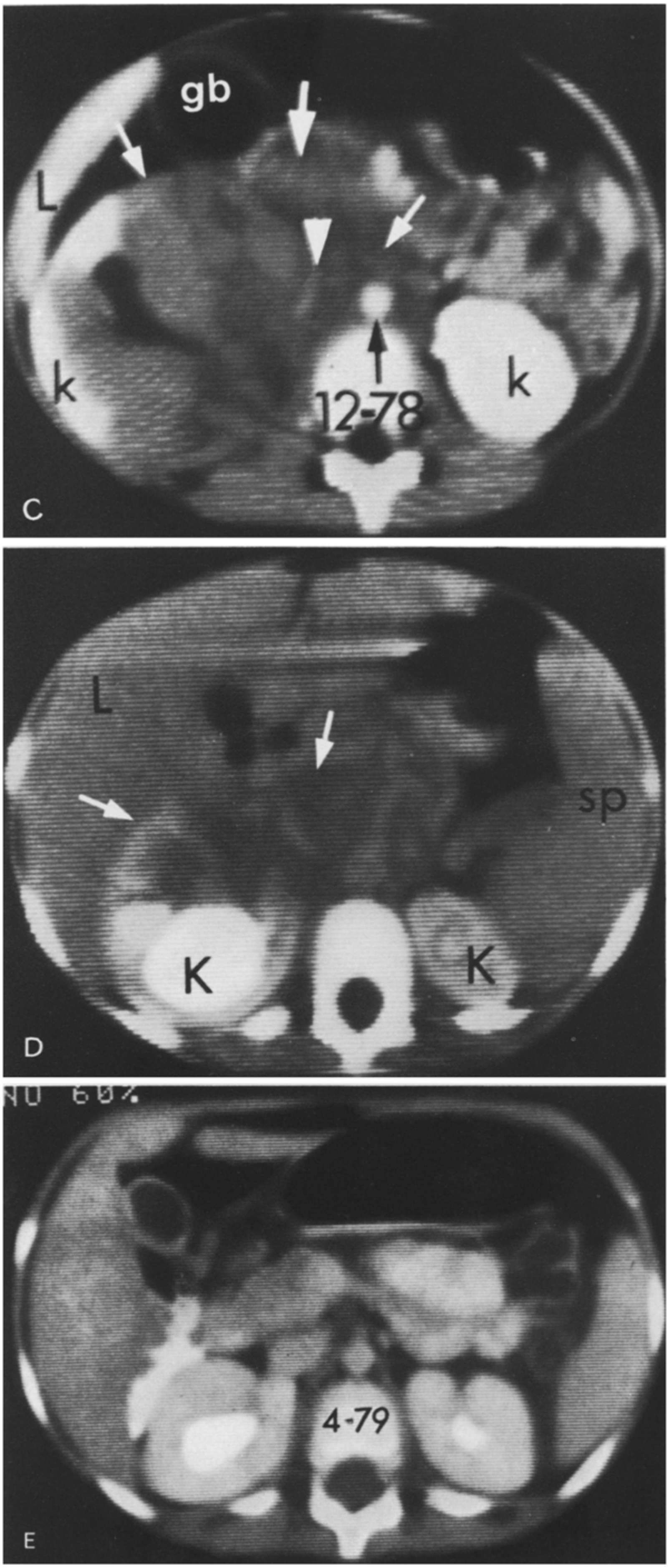


Fig. 5 A–E. C CT scan demonstrates intrinsic right renal mass (white arrows) encasing aorta (black arrow) and extrinsically compression of inferior vena cava (white arrowhead). **D** CT scan 4 cm cephalad to (C) demonstrates extension of mass to porta hepatis, dilatation of distal biliary ducts and large spleen. CT impression confirmed by biopsy of mass: renal lymphoma. **E** CT three months following chemotherapy demonstrated normal appearing right kidney and no evidence of residual tumor

tumors involving the renal, perirenal, and retroperitoneal areas, we feel that CT is not only justified, but is the definitive prospective investigation.

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