9 Urinary Tract

The study of the urinary tract mingles mechanical, hemodynamic, and infectious disorders. Normal kidney and bladder are described in Chap. 4.

Our 5-MHz microconvex probe is fully suitable for this investigation.

Renal Parenchyma

The diagnosis of acute renal failure is biological. A main purpose of ultrasound is to rule out an obstacle [1]. The ultrasound patterns usually give redundant information, as we will briefly discuss. Acute renal failure is suggested when there is normal or increased size (Fig. 9.1). Chronic renal failure may cause small kidneys with thin parenchyma and irregular borders (Fig. 9.2). Kidneys can show global dedifferentiation. The parenchyma can resemble the sinus (parenchymo-central dedifferentiation); within the parenchyma, medullary pyramids, and cortex, it can have the same echogenicity (corticomedullary dedifferentiation). In the case of severe rhabdomyolysis with acute renal failure, we can observe enlarged kidneys with complete dedifferentiation. Hemolytic uremic syndrome should yield small hyperechoic kidneys. The use of Doppler for calculating renal resistance index may be of interest, but does not seem to be of major relevance for acute decision-making from various sources.

Acute pyelonephritis is usually barely or not accessible to two-dimensional ultrasound, but severe forms, such as hemorrhagic pyonephritis, are sometimes diagnosed. Figure 9.3 shows the routine ultrasound of a 52-year-old female who was admitted for severe sepsis, with massive bilateral enlargement of the kidneys and no differentiation.

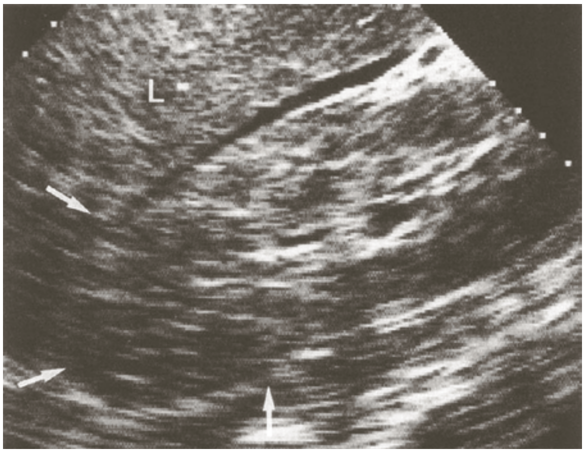

Fig. 9.1 Acute renal failure. The kidney has a homogeneous echoic pattern, i.e., complete dedifferentiation. Kidney and liver (*L*) have the same echogenicity, and the kidney is barely outlined (*arrows*). This scan, as nearly all that follow, is longitudinal

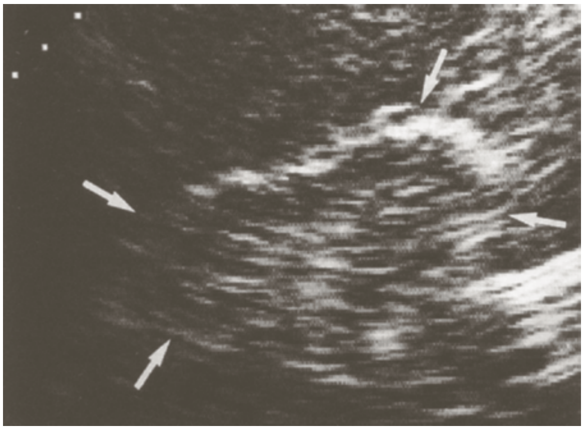

Fig. 9.2 Chronic renal failure. Small size (*arrows*), thinned parenchyma and irregular borders

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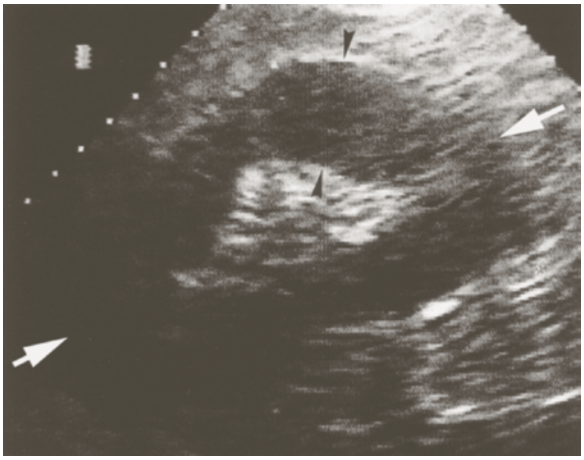

Fig. 9.3 Pyonephritis. This kidney is frankly enlarged (long axis, 14 cm, *white arrows* – the *upper arrow*, left of the screen, extrapolates the upper pole of the kidney) and the peripheral area is extremely thickened (*arrowheads*), without differentiation. This shocked patient had an acute hemorrhagic pyonephritis. Each kidney weighed 500 g and contained multiple areas with pus, necrosis and hemorrhage

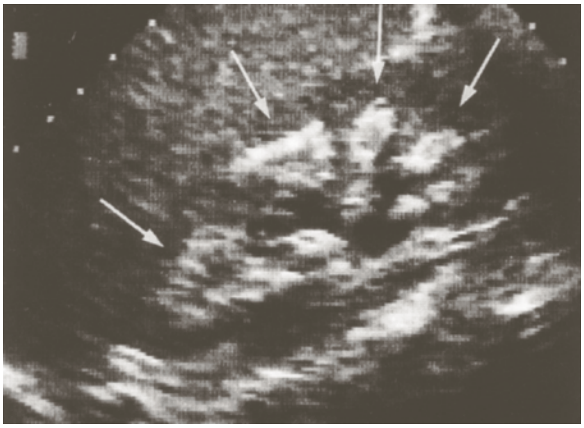

Fig. 9.4 Urinary candidosis. Hyperechoic pattern of the pyramids (*arrows*)

Parenchymatous candidiasis can sometimes be diagnosed (Fig. 9.4). Emphysematous pyelonephritis, a rare finding, shows gas bubbles within the parenchyma. Renal trauma is presented in Chap. 25.

In the case of grafted kidney, ultrasound plays a significant role in detecting surgical postoperative complications that can be caused by abscess, hematoma, lymphocele or urinoma. They can be explored with an ultrasound-guided tap. Dilatation of the calices suggests obstruction caused by edema or anastomotic stenosis of the ureter. Stenosis of the renal artery is an indication of Doppler. This rare complication, which can require the DIAFORA logistics, is not in the field of this textbook. Medical complications are traditionally not from the field of ultrasound, in spite of numerous signs of acute or chronic rejection, cyclosporine toxicity or tubulointerstitial nephritis. They are generally diagnosed by renal biopsy [2], yet some recent ultrasonic approaches may be interesting [3].

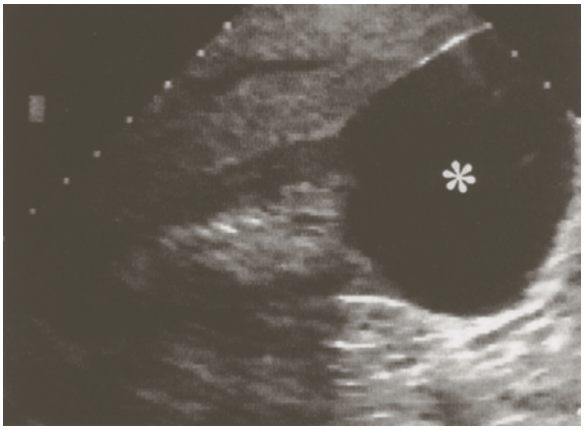

Fig. 9.5 Renal cyst (*asterisk*). The lower pole of the kidney seems to be interrupted, with a ragged edge. This cyst is regular, anechoic. This pattern (featuring here because of its frequency) should not disconcert

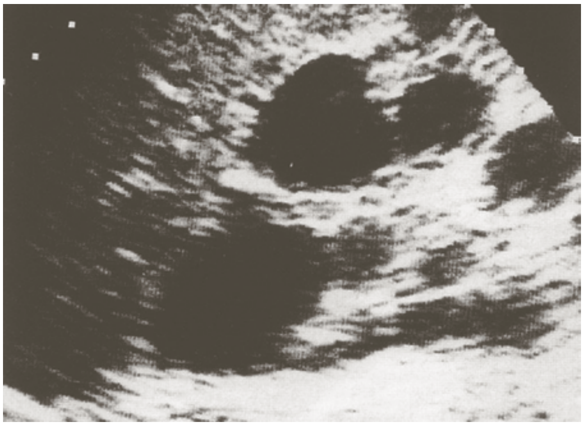

Fig. 9.6 Renal polycystic disease. Cysts have peripheral topography and do not communicate with each other, two features that distinguish them from dilatation of the urinary cavities

Renal cysts are frequent findings. In view of its frequency, we insert a characteristic example (Fig. 9.5), and a case of renal polycystic disease (Fig. 9.6). These cysts do not communicate with each other, and will therefore not be confused with renal pelvis dilatation. The renal cyst is one of the very infrequent diseases induced by ultrasound: the first discovered cysts were nearly systematically surgically removed.

Dilatation of the Renal Pelvis

Facing daily troubles (drop in diuresis, etc.), the possibility of a urinary obstacle can be ruled out in a few seconds. Dilated calices and renal pelvis yield familiar patterns. The three calices and the pelvis, normally barely visible, are clearly depicted, anechoic, communicating with each other (Fig. 9.7). In acute obstacle, the dilatation is rather moderate, with the end of the calyces keeping their concavity. Large dilatation with bulge-ended calices comes rather from chronic obstructions (Fig. 9.8). The ureter (Fig. 9.9) is often hidden by the abdominal structures.

Dilatation of the renal pelvis is rarely but regularly encountered in our experience. Of 400 consecutive critically ill patients in the ICU, 2% had pelvis dilatation, a rate that would increase markedly if only sepsis or acute renal failure were considered. The pain is rarely present in these septic, encephalopathic patients; hence a routine ultrasound examination should be given to any critically ill patient. Causes encountered were pelvic hematoma, bladder distension that is sometimes due to urinary probe obstruction (Fig. 9.10), calculi, blood clot, or hydronephrosis (Fig. 9.8) with superimposed pyonephrosis (Fig. 9.11).

A dilatation without obstacle is seen exceptionally. It could be due to previous chronic infections or the ampullary pelvis, a variant of the norm for some that occurs in 8% of the population [4], the sign of occult obstruction for others [5]. We used to consider a unilateral and moderate dilatation in a septic patient as clinically relevant. A pattern looking like a dilatation, in a hasty examination, is the parapyelic cyst.

Detection of dependent echoic patterns within dilated cavities of hydronephrosis is characteristic of pyonephrosis [6].

Absence of dilatation in spite of an obstacle is rare (we have not yet seen this situation), explainable by decrease in compliance (retroperitoneal fibrosis, etc.), and usually deserving iodine explorations [7–9]. Major hypovolemia should be an associated factor.

Fig. 9.7 Mild dilatation of the cavities. The pelvis is slightly more dilated. The end of the calyces is concave (*arrows*), usually a sign of acute obstruction. Longitudinal scan, making it possible to visualize the three calyx groups

Fig. 9.8 Hydronephrosis. Major dilatation of the renal pelvis. Note the rounded end, which indicates chronic obstruction. This single scan does not show patent signs of acute infection (see Fig. 9.11). Septic shock, transverse scan of the right kidney

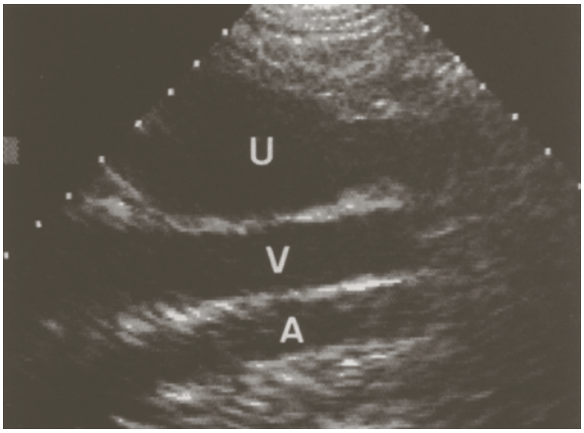

Fig. 9.9 Ureter. In this longitudinal scan of the right flank, one can observe a dilated ureter (*U*), inferior vena cava (*V*) and abdominal aorta (*A*). This is a privilegiated view. The ureter is usually masked by bowel gas

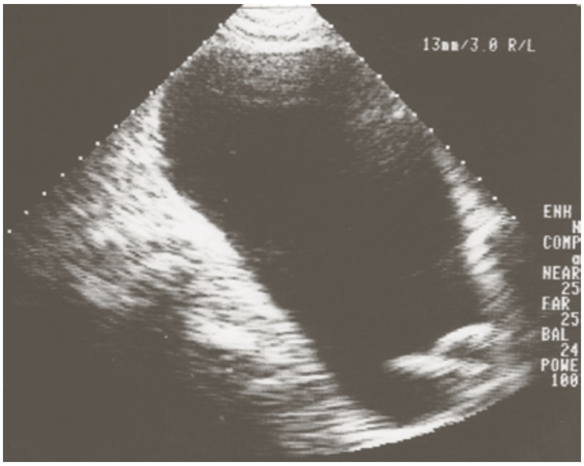

Fig. 9.10 Major bladder distension. Note that it occurred in spite of a urinary probe. The balloon and the end of the probe are visible at the bottom. The probe was obstructed. Longitudinal suprapubic scan

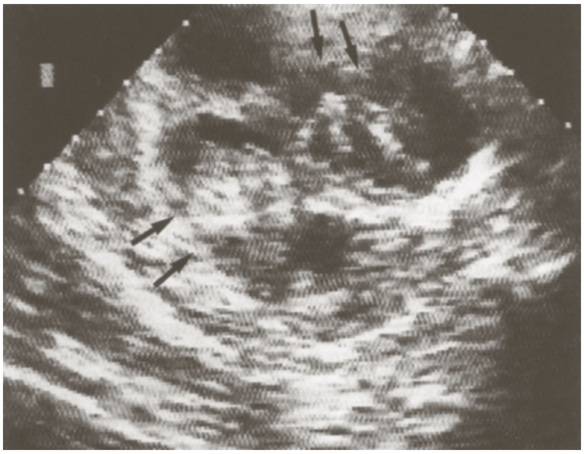

Fig. 9.11 Pyonephrosis. The ultrasound scan of this kidney with hydronephrosis shows heterogeneous echoic masses within the dilated cavities (*arrows*). These images had a undulating motion in real-time. The diagnosis of superimposed infection can now be assumed

Renal Vessels

We advise the reader to get accustomed to checking for the renal veins, especially the left, which is a substantial anatomic part of the abdomen. It crosses from the left (kidney) to the right (inferior vena cava), which cannot be missed in the absence of clouds (gas). We use it for having a reproducible area for measuring the inferior vena cava far from the heart. Other relevant uses are under study.

Bladder

The technique requires a "diving" approach, just above the pubis, made easier using a microconvex probe (Fig. 9.12). As a rule, a catheterized bladder is empty. The balloon of the probe can be detected, round structure lost in the pelvis, always medial (Fig. 9.12).

Distended bladder may be one of the most obvious diagnoses for the beginner in ultrasound (Fig. 9.10). The probe detects a fluid mass which is medial, round, near

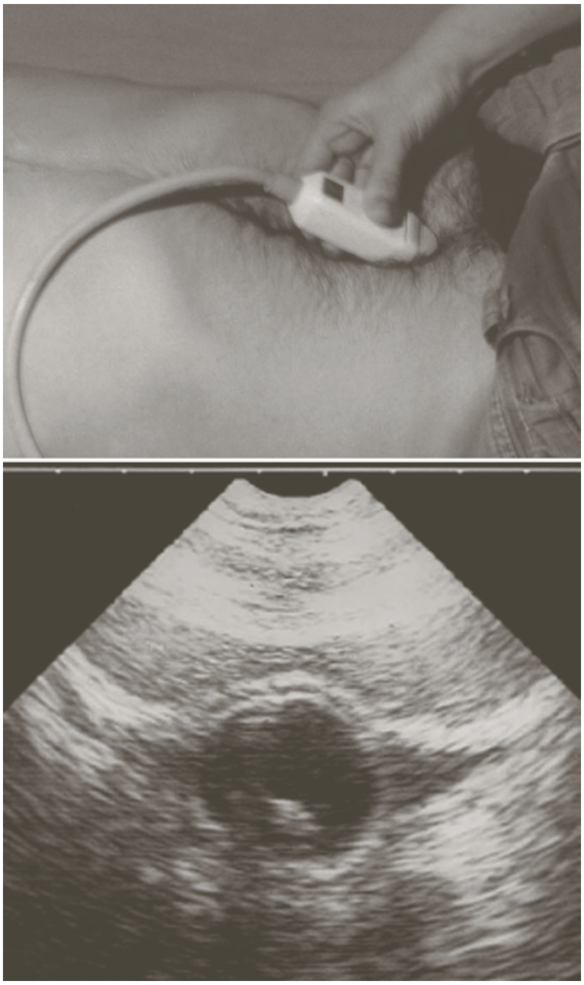

Fig. 9.12 Probed bladder. *Top:* For searching a bladder in the pelvis, we apply the probe nearly parallel to the abdominal wall, pointing to the posterior and inferior direction. Abdominal probes are too cumbersome for this subtle maneuver. This figure is used again for the subcostal heart analysis: just imagine the probe inclined in the same way. *Bottom:* In this suprapubic transversal scan, one can see a regular round and medial structure, the inflated balloon of the urinary probe. The bladder is here correctly drained, thus virtual

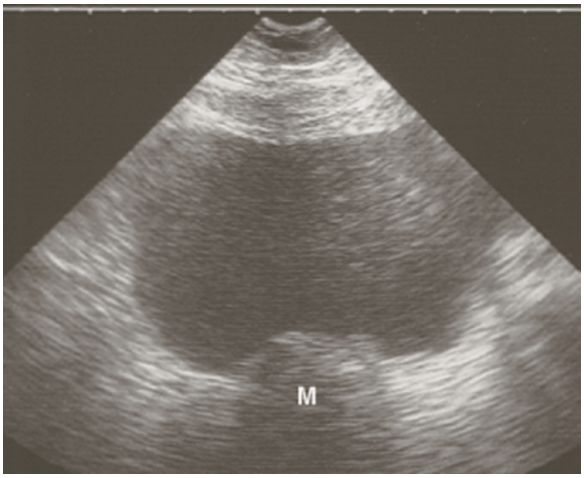

Fig. 9.13 In a suprapubic transversal scan, this medial fluid image with square section may mimic a moderately distended bladder, with a tissular image (*M*) mimicking a prostate. It is in fact a peritoneal effusion in the Douglas pouch. The image at *M* is probably a bowel loop. A dynamic scan upward and downward (large Carmen maneuver) will prevent the error: the bladder will be identified below, and this fluid image will have an opened shape above (with the bat wing sign)

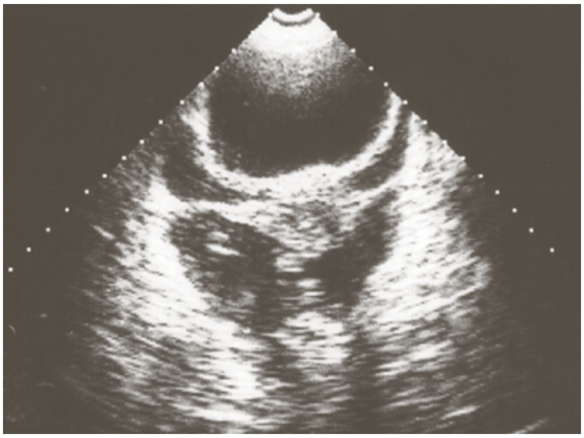

Fig. 9.14 Thai dragon sign. This complex transverse suprapubic scan may intrigue the operator. One can imagine the head of a Thai dragon. This full bladder is associated with peritoneal effusion in a young woman. The bladder is the round shape at the top of the screen. The eyes and the grinning mouth of the dragon reflect the peritoneal effusion. The nose is formed by the uterus and the large ligaments. The teeth are generated by structures floating in the effusion – a hemoperitoneum here

the anterior wall, roughly 10 cm or more in a transverse section. Ultrasound is useful, in particular, in obese patients, where the physical examination is difficult. The pitfalls are easily avoidable. The most frequent is the peritoneal effusion that mimics a distended bladder (Fig. 9.13). See comment on page 35 in Chap. 5.

In the female, the association of peritoneal effusion with a full bladder yields a complex but characteristic pattern, with the suggested name of the Thai dragon-head sign (Fig. 9.14).

A probed bladder that is not empty indicates an abnormal finding (Fig. 9.10). It should be repeatedly examined in order to check an increase of trapped volume. The situation can evolve into a urinary obstacle. Often, in the blind times of intensive care, the sedated patient develops such a complication, which is labeled "anuria," prompting hemodynamic explorations before the distension is clinically detectable. Facing any acute patient under hemodynamic therapy, our fast protocol devotes a few seconds to checking for the absence of bladder distension.

In an anuric patient, a daily ultrasound will detect recovery of diuresis. This rapid procedure prevents a prolonged and useless urinary probe.

The bladder content is informative. Pyuria and blood are responsible for echoic dependent patterns (Fig. 9.15). A calculus gives a dependent image with a frank posterior shadow. An enlarged prostate can be detected (Fig. 9.16).

Some want to know the volume of the urine. By assimilating the bladder to a sphere, taking only one of its dimensions (the easiest, i.e., the transversal distance in a transversal scan) and using the simple mathematic formula for a sphere volume would give a rough and satisfactory estimation. Roughly, by taking only this transversal distance, a 5-cm distance corresponds approximately to 100 mL, a 6-cm distance corresponds to 175 mL, a 7-cm distance corresponds to 250 mL, and an 8-cm distance corresponds to 425 mL.

Uterus, Adnexa, Fertility Organs

We like to take a routine look at the uterus (Figs. 9.17 and 5.5 page 34). An acute disorder in a pregnant woman raises problems [10]. Most current investigations require irradiating tests. If a pregnancy is detected (Fig. 9.18), the reader can refer to Chap. 29, where details about practical management are provided. For this emergency application, we do not need to await full repletion of the bladder. In some cases where the suprapubic approach is impossible (dressings), it is fully

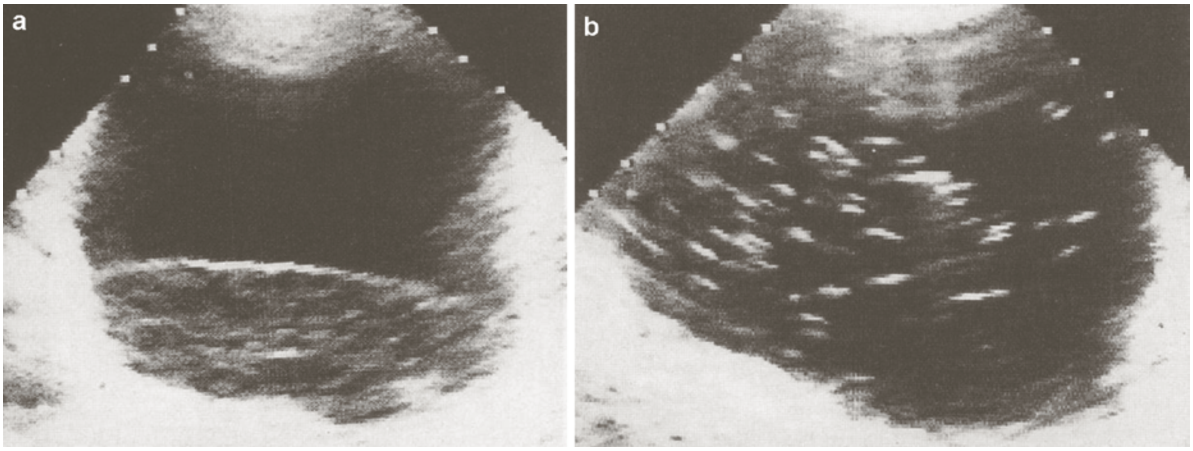

Fig. 9.15 Pyuria. (**a**) Two elements can be distinguished in this bladder, separated by an artifactual line: a dependent echoic sediment and a nondependent anechoic area. Pyuria. Transverse scan of the bladder. (**b**) Another pattern of pyuria. Multiple hyperechoic elements as in weightlessness, indicating microbial gas

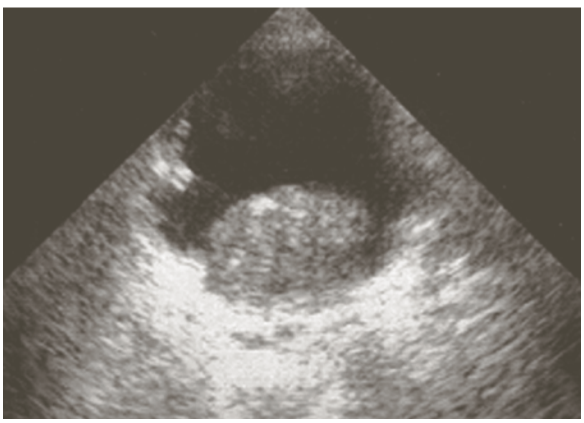

Fig. 9.16 Prostatic adenoma. Typical medial regular tissular mass protruding in the bladder lumen. This finding can be a cause of acute obstructive renal failure. Note the low image resolution, issuing from a cardiac probe

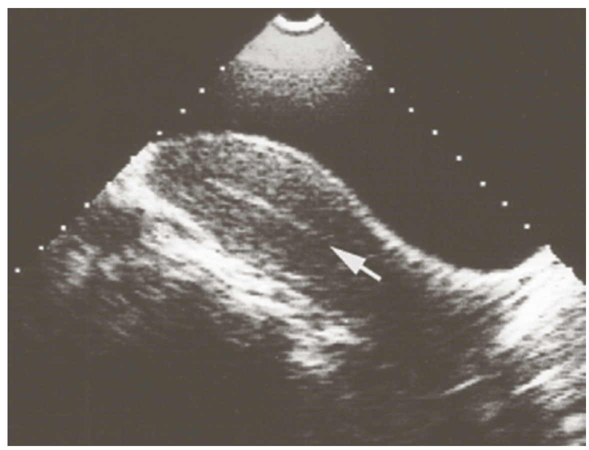

Fig. 9.17 Empty uterus. Long-axis scan, behind the bladder. The vacuity line (*arrow*: endometrial stripe) frankly outlined within the uterine muscle indicates absence of pregnancy

possible to use either a perineal approach, or, more invasive, an endovaginal approach using our microconvex probe covered by a simple glove. This is a typical example of nonacademic but relevant use of critical ultrasound for diagnosing pelvic fluid, for instance.

Ectopic pregnancy shows subtle direct images for the specialist, and a rough indirect image for the nonspecialist, the hemoperitoneum. The reader is not required to locate an interstitial or cervical pregnancy, but rather to make a fast examination of the peritoneum in order to early detect free blood. Any free fluid in this setting should prompt referral to surgery (if possible by obstetricians, in order to save the adnexa), not waiting the evolution of the bleeding. If the surgeon is reluctant or initiates speculative talks about the nature of the fluid (as regularly happened to us, when the potential of critical ultrasound was not yet routine in our surgeons' minds), a fast needle tap will confirm the bleeding and save a life. The pelvic blood can be echoic at the first examination (Fig. 9.19).

Emergency physicians will often face pregnant women with various acute concerns (molar pregnancy, uterine apoplexy, or others). These cases will not be detailed here, but are available elsewhere in the literature. Basically, a woman with positive pregnancy test has usually, at the early stage, a gestational sac instead of the endometrial stripe, containing eventually a fetal

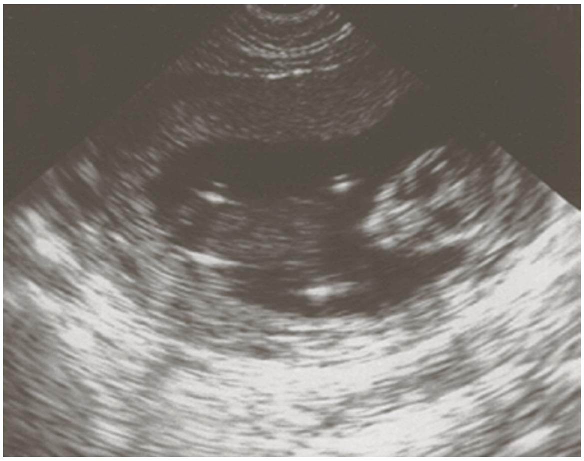

Fig. 9.18 Like a cat turned on its back, head at the right of the image, seemingly observing the viewer, an embryo is visible in the uterus. Here the physician is invited not to overindulge in ionizing radiation procedures, what ultrasound makes possible at the whole body

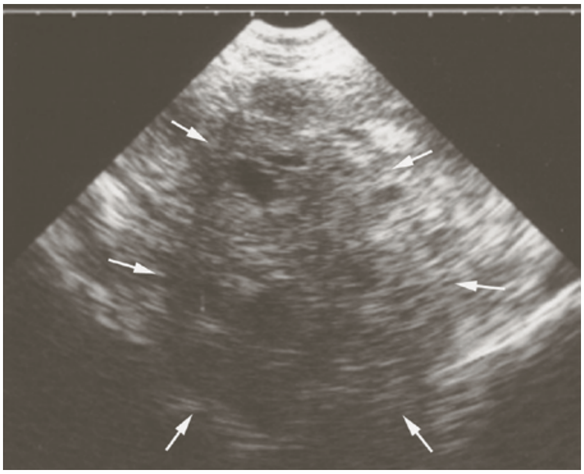

Fig. 9.19 Ectopic pregnancy. This transverse view of the Douglas pouch in a young shocked female immediately confirms the diagnosis, showing a motionless echoic mass (*arrows*) indicating a massive blood clot. Compare with an anechoic effusion in the same incidence, in Fig. 9.13. The Carmen maneuver was more demonstrative that this static image, taken in extreme emergency. The intensivist should not be asked the precise site of the pregnancy, since the recognition alone of a peritoneal effusion, even clotted, indicates immediate life-saving surgery

pole with heart beats, and a yolk sac (round, empty structure). Endometritis produces diffuse edema of the parenchyma [11]. Pyometritis gives a fluid endouterine image. Hyperechoic punctiform images (gas) are a strong argument if there is severe pelvic sepsis [11].

In the young male, the emergencies are not life-threatening, but fertility-threatening. This is discussed in Chap. 28.

Interventional Ultrasound

Percutaneous Nephrostomy

It is possible to treat a urinary obstruction and to drain infected urine at the bedside if ultrasound-guided. The kidney is punctured by the posterior or posterolateral approach (avoiding the colon and the pleura). A needle is inserted in the dilated cavities. Urine is collected for analysis. A guide is then introduced through the needle. A drainage catheter is inserted, sometimes after some dilatations. It is possible, as we did, to use this technique for immediately relieving highly unstable patients with severe septic shock and difficulties of transfer to an operating room. The traditional management can be done later (removing the calculus in the interventional radiology department) in a stabilized patient.

Percutaneous nephrostomy has a mortality rate (0.2%) that is reportedly lower than that of surgery [4]. Complications include hemorrhage or infection and should be balanced with the advantages.

Suprapubic Catheterization

Ultrasound guidance provides visual monitoring. A penetration site more cranial than classically done should theoretically limit the risk of sepsis of the prevesical space. Digestive interpositions can then be checked using ultrasound. Using ultrasound, the operator does not need to wait for massive repletion of the bladder.

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