individuals with calcium stones, no cause can be found (idiopathic calcium stone disease).

- *Magnesium ammonium phosphate stones* are formed largely after infections by urea-splitting bacteria (e.g., *Proteus* and some staphylococci) that convert urea to ammonia. The resultant alkaline urine causes the precipitation of magnesium ammonium phosphate salts. These form some of the largest stones, as the amount of urea excreted normally is very large. Indeed, so-called *staghorn calculi* occupying large portions of the renal pelvis are frequently a consequence of infection.
- *Uric acid stones* are common in individuals with hyperuricemia, such as patients with gout, and diseases involving rapid cell turnover, such as the leukemias. However, **more than half of all patients with uric acid calculi have neither hyperuricemia nor increased urinary excretion of uric acid.** In this group, it is thought that a tendency to excrete urine of pH below 5.5 may predispose to uric acid stones, because uric acid is insoluble in acidic urine. In contrast to the radiopaque calcium stones, uric acid stones are radiolucent.
- *Cystine stones* are caused by genetic defects in the renal reabsorption of amino acids, including cystine, leading to cystinuria. These stones also form at low urinary pH.

It can therefore be appreciated that **increased concentration of stone constituents, changes in urinary pH, decreased urine volume, and the presence of bacteria influence the formation of calculi.** However, many calculi occur in the absence of these factors; conversely, individuals with hypercalciuria, hyperoxaluria, and hyperuricosuria often do not form stones. It has been postulated that stone formation is enhanced by a deficiency in inhibitors of crystal formation in urine. The list of such inhibitors is long, including pyrophosphate, diphosphonate, citrate, glycosaminoglycans, osteopontin, and a glycoprotein called nephrocalcin.

MORPHOLOGY

Stones are unilateral in about 80% of patients. The favored sites for their formation are within the renal calyces and pelves (Fig. 20-49) and in the bladder. If formed in the renal pelvis they tend to remain small, having an average diameter of 2 to 3 mm. These may have smooth contours or may take the form of an irregular, jagged mass of spicules. Often many stones are found within one kidney. On occasion, progressive accretion of salts leads to the development of branching structures known as staghorn calculi, which create a cast of the pelvic and calyceal system.

Clinical Features. Urolithiasis may be asymptomatic, produce severe renal colic and abdominal pain, or may cause significant renal damage. Larger stones often manifest themselves by hematuria. Stones also predispose to superimposed infection, both by their obstructive nature and by the trauma they produce.

Neoplasms of the Kidney

Both benign and malignant neoplasms occur in the kidney. Malignant neoplasms are of great importance clinically. By far the most common malignant tumor is renal cell carcinoma, followed by Wilms tumor, which is found in children and is described in Chapter 10, and finally urothelial carcinomas of the calyces and pelves.

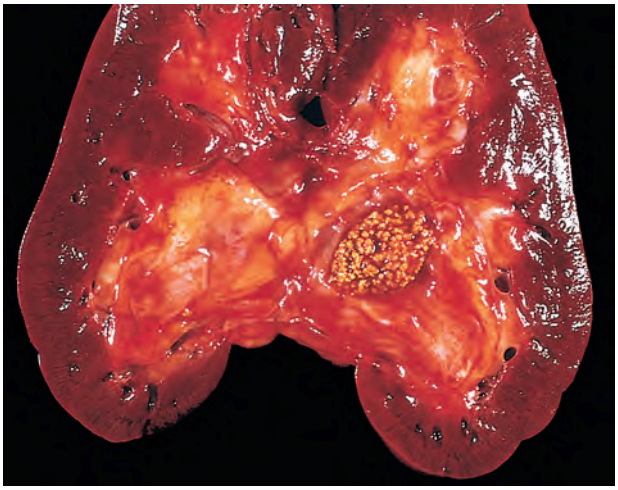

Figure 20-49 Nephrolithiasis. A large stone impacted in the renal pelvis. (Courtesy Dr. E. Mosher, Brigham and Women's Hospital, Boston, Mass.)

Benign Neoplasms

Renal Papillary Adenoma

Small, discrete adenomas arising from the renal tubular epithelium are found commonly (7% to 22%) at autopsy. They are most frequently papillary and are therefore called *papillary adenomas*.

MORPHOLOGY

These are small tumors, usually less than 0.5 cm in diameter. They are present invariably within the cortex and appear grossly as pale yellow-gray, discrete, well-circumscribed nodules. On microscopic examination, they are composed of complex, branching, papillomatous structures with numerous complex fronds. Cells may also grow as tubules, glands, cords, and sheets of cells. The cells are cuboidal to polygonal in shape and have regular, small central nuclei, scanty cytoplasm, and no atypia.

By histologic criteria, these tumors do not differ from low-grade papillary renal cell carcinoma and indeed share some immunohistochemical and cytogenetic features (trisomies 7 and 17) with papillary cancers, to be discussed later. The size of the tumor is used as a prognostic feature, with a cutoff of 3 cm separating those that metastasize from those that rarely do. However, because of occasional reports of small tumors that have metastasized, the current view is to regard all adenomas, regardless of size, as potentially malignant.

Angiomyolipoma

This is a benign neoplasm consisting of vessels, smooth muscle, and fat originating from perivascular epithelioid cells. **Angiomyolipomas are present in 25% to 50% of patients with tuberous sclerosis,** a disease caused by