CT of the Body in Children

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Should I get a CT scan on my patient? This is a question frequently asked by pediatricians and one not always easily answered. Before the advent of CT, ultrasound, radionuclide, and most recently, magnetic resonance scans, the selection of an imaging procedure was much simpler. Compounding the dilemma resulting from having many tests capable of giving similar information is the greater need for cost control in today's medical environment. The pediatrician, therefore, needs to know the relative costs and benefits of the various options in order to make an informed choice after consulting with the radiologist.

TECHNIQUES, PROBLEMS AND SOLUTIONS

Optimal CT examination in children requires the use of a modern scanner capable of scan times less than 5 seconds; generally the shorter the time, the better. The radiologist performing the examination should be familiar with the use of CT in children including the necessity for sedation and immobilization as well as the proper use of contrast enhancement techniques.1

Patient Motion

A moving child cannot be properly examined by CT. Children of preschool age cannot be expected to cooperate by breath holding or even by lying still, so a combination of sedation and restraint is necessary. Restraints can be simple such as wrapping a child with a blanket or using an Ace bandage to fasten the child to a board or other immobilization device. Usually from 6 months to 6 years of age sedation is needed in addition to restraints. There are many sedation protocols which are effective; those used at the Children's Hospital of Buffalo are listed in Table 1.

Small Structures and Lack of Natural Fat

Body fat provides natural contrast for many structures in adults but in children not only are the organs smaller but also body fat is scant, making separation of structures difficult; this means that contrast must be provided artificially. When examining the abdomen, it is necessary to opacify the small bowel and occasionally the colon so as to separate bowel loops from possible pathology. We have the child drink a mixture of dilute meglumine diatrizoate (Gastrografin) and orange juice. Dilute meglumine diatrizoate enemas are used if the pelvis is being studied.1 For nearly all abdominal and mediastinal cases, intravenous contrast enhancement is also necessary. The contrast medium is injected as a rapid bolus, with serial scans being performed as quickly as possible so that information on vascular and parenchymal phases is not wasted. The old concept of "total body opacification" is nowhere better exemplified than in this phase when the whole child "lights up." The dose recommended is 2 to 3 cc/kg of 60% meglumine diatrizoate up to 100 cc. A younger child should have an intravenous catheter inserted when he is sedated so that the injection can be monitored. However, room staff can monitor this easily.

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### TABLE 1
SEDATION GUIDELINES FOR RADIOLOGY PROCEDURES

<table>
<thead>
<tr>
<th>CHILDREN LESS THAN 2 YEARS OF AGE</th>
<th>CHILDREN GREATER THAN 2 YEARS OF AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1) CM#3</strong></td>
<td><strong>1) Pentobarbital Sodium (Nembutal)</strong></td>
</tr>
<tr>
<td>Administered on ward</td>
<td>2 mg/kg IV</td>
</tr>
<tr>
<td>[Disadvantages: difficult to control time of administration; difficult to add additional drugs if sedation is inadequate]</td>
<td>(100 mg maximum dose)</td>
</tr>
<tr>
<td>Can repeat @ 25-50 mg/kg PO × 1</td>
<td>3-5 mg/kg IM</td>
</tr>
<tr>
<td></td>
<td>maximum: 100 mg</td>
</tr>
<tr>
<td></td>
<td>3-4 mg/kg 10 kg and under</td>
</tr>
<tr>
<td></td>
<td>4-5 mg/kg 10 kg and above</td>
</tr>
<tr>
<td><strong>2) Chloral hydrate (Noctec Syrup)</strong></td>
<td><strong>2) Fentanyl (Sublimaze)</strong></td>
</tr>
<tr>
<td></td>
<td>50 mg/kg PO</td>
</tr>
<tr>
<td></td>
<td>maximum single dose 1 g</td>
</tr>
<tr>
<td></td>
<td>Then titrate with additional doses of 1 μg/kg IV PRN:</td>
</tr>
<tr>
<td></td>
<td>Usually will not exceed total of 4 to 5 μg/kg. At higher doses noticeable nasofacial itching occurs which keeps child awake.</td>
</tr>
<tr>
<td></td>
<td>When used in conjunction with other drugs. Very effective after Nembutal, if child is almost asleep. May be followed by Nembutal (or Fentanyl). Very effective in children with behavior problems. Give IV over 3-min period. Do not mix with other medications or dilute.</td>
</tr>
<tr>
<td><strong>3) Pentobarbital Sodium (Nembutal)</strong></td>
<td><strong>3) Diazepam (Valium)</strong></td>
</tr>
<tr>
<td></td>
<td>3-5 mg/kg IM, PO</td>
</tr>
<tr>
<td></td>
<td>(3-5 mg/kg 10 kg and under; 4-5 mg/kg 10 kg and above)</td>
</tr>
<tr>
<td></td>
<td>(maximum: 100 mg)</td>
</tr>
<tr>
<td></td>
<td>1 μg/kg IV</td>
</tr>
<tr>
<td></td>
<td>0.2 mg/kg PO/IV</td>
</tr>
<tr>
<td></td>
<td>maximum 0.4 mg/kg</td>
</tr>
<tr>
<td><strong>ANTIDOTE</strong></td>
<td><strong>Effective for narcotics (morphine, fentanyl). Given at 2 to 3 minute intervals until desired response is obtained.</strong></td>
</tr>
<tr>
<td>Naloxone (Narcan)</td>
<td></td>
</tr>
<tr>
<td>0.01 mg/kg IV</td>
<td></td>
</tr>
</tbody>
</table>

**Beware**

Children on barbiturates are more sensitive to other drugs, particularly those causing respiratory depression. Therefore, those children are more apt to suffer significant respiratory depression.

Children previously on chronic barbiturate therapy, e.g., seizures, are more apt to suffer from respiratory depression if combination of Nembutal and Fentanyl is given. Therefore, Fentanyl is usually not given.

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Radiation Exposure

Parents and pediatricians alike are acutely aware of the possible risks of radiation in children and CT does require the use of ionizing radiation. How much radiation exposure a child receives from a CT scan varies somewhat with the equipment used, the exposure factors and the number of slices obtained. A range of skin exposure from 0.9 rads to 5.6 rads has been reported. By comparison, an excretory urogram would expose a child to an average of 0.3 rads and an abdominal angiogram would deliver an exposure of about 10 rads. The relative risk from this radiation exposure can be compared to risks of everyday life as shown in Table 2.

Cost

CT is a relatively expensive diagnostic procedure but not prohibitively priced when compared with the possible benefits obtained. There is, of course, wide variation in cost from place to place but, in general, CT is 1.5 to 2.0 times more expensive than ultrasound; 1.5 times as costly as nuclear medicine, but less than half as costly as an angiogram or MRI study. Compared to urography and barium studies, CT averages about twice as much. It must be remembered, however, that CT is often capable of replacing one or more of these other studies and when used appropriately may actually produce a cost savings. CT is generally less expensive than a day in the hospital and prompt and accurate diagnosis will expedite therapy thus lowering overall cost.
### TABLE 2

**RISK COMPARISONS**

<table>
<thead>
<tr>
<th>Risks</th>
<th>Loss in Life Expectancy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Common</strong></td>
<td></td>
</tr>
<tr>
<td>Smoking a cigarette</td>
<td>10 min</td>
</tr>
<tr>
<td>Overweight</td>
<td>2.7 yr</td>
</tr>
<tr>
<td>Home accidents</td>
<td>95 days</td>
</tr>
<tr>
<td>Coal mining from age 20</td>
<td>155 days</td>
</tr>
<tr>
<td>Construction employment from age 20</td>
<td>94 days</td>
</tr>
<tr>
<td><strong>Ionizing Radiation</strong></td>
<td></td>
</tr>
<tr>
<td>Radiation, 1 mrad</td>
<td>1.5 min</td>
</tr>
<tr>
<td>Occupational exposure, 1 rem</td>
<td>1 day</td>
</tr>
<tr>
<td>Medical x-ray examinations†</td>
<td>6 days</td>
</tr>
<tr>
<td>(US average)</td>
<td></td>
</tr>
<tr>
<td>Radiation work</td>
<td>68 days</td>
</tr>
<tr>
<td>5 rem/yr from age 20</td>
<td>7 days</td>
</tr>
<tr>
<td>Radiation work</td>
<td></td>
</tr>
<tr>
<td>500 mrem/yr from age 20</td>
<td></td>
</tr>
</tbody>
</table>

† Estimate calculated from US population exposure estimates (1980) of 93 mrem/yr.

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**INDICATIONS**

There are many indications for CT examination of the body in children but lack of space precludes extensive discussion. I will summarize the general indications and, where possible, briefly discuss some of the more important ones.

**Musculoskeletal CT**

Most pediatric bone and joint diseases are studied primarily by plain radiography and to some extent with nuclear medicine but there are some indications for the use of CT (Table 3). CT is useful in evaluation of pediatric bone tumors. Osteochondromas and osteoid osteomas are benign bone tumors which can be optimally localized with CT if necessary after preliminary radiographic study. In osteosarcoma, CT is useful to delineate the extent of the soft tissue mass. More importantly, if something less than total amputation is considered, CT seems to provide an accurate assessment of intramedullary extent of tumor, at least in large long bones such as the femur.

Ewing's sarcoma is more likely to occur in flat bones such as the ribs and pelvis. CT is again the best way to assess the size of the soft tissue mass and its relationship to surrounding structures (Figure 1A, B) and is therefore particularly useful to follow results of therapy. Differentiation of Ewing's sarcoma from inflammatory disease is not always possible however, especially in lesions involving the ribs and sternum.

Soft tissue masses are well localized with computed tomography although differentiation of tumor from an inflammatory mass is not always possible. Sarcomas may enhance as much as an abscess. Neurofibromas are seen as homogeneous, smoothly margined, cylindrical lesions having a density slightly lower than that of muscle. The location in the neuromuscular bundle may suggest the correct diagnosis. Low-density avascular areas within a neurofibroma suggest fibrosarcomatous degeneration.

CT can be of benefit in the diagnosis of osteomyelitis. The marrow of the opposite, presumably normal, extremity serves as a control. This technique has not been useful in small bones or flat bones.

CT also is useful in the diagnosis of other bone pathology when the radionuclide bone scan is positive and the radiographs fail to demonstrate a definite...
pathologic abnormality. This is especially true in the vertebrae and the bones of the pelvis. CT also is the best way to delineate the presence of sequestrum (Figure 2).

Because of its good contrast resolution and the axial view, CT is useful in the detection and localization of foreign bodies and can help in planning the surgical approach. Foreign bodies which are non-opaque, ie, wood, can usually be readily detected by CT.

CT is now preferred to conventional tomography for evaluation of areas such as the sternoclavicular joint, the sternum and the pelvis. Diagnosis of suspected tarsal bars has been simplified by CT.5,7

CT has been useful in pediatric hip disease as well. Determining the adequacy of reduction of congenital dislocation of the hip, following application of a plaster cast, can be simplified by computed tomography. Measuring the angle of anteversion, a study previously difficult to do, is well done by computed tomography requiring only one or two sections through the femoral neck and distal femur to obtain accurate and reproducible measurements.8

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**TABLE 3**

INDICATIONS FOR MUSCULOSKELETAL COMPUTED TOMOGRAPHY IN CHILDREN

1. Bone tumors
2. Soft tissue masses
3. Osteomyelitis
4. Foreign body localization
5. Alternate tomographic examination
6. Hips and pelvis
   a) Congenital dislocated hip
   b) Anteverision
   c) Trauma
   d) Sacroiliac joints

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**TABLE 4**

INDICATIONS FOR CT OF THE THORAX IN CHILDREN

1. Lung
   a) Chest wall disease
   b) Opaque lung
   c) Foreign bodies
   d) Metastatic disease
   e) Localization and characterization of pulmonary densities
2. Mediastinum
   a) Evaluation of thymus
   b) Hilar and mediastinal adenopathy
   c) Evaluation of mediastinal masses—characterization and extent
   d) Airway compression

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**Figure 2.** CT scan made parallel to the long axis of the humerus in the patient with chronic osteomyelitis documents the presence of an intramedullary sequestrum. (Arrow in the humerus, H/R radius, U ulna).

CT has been of value in detection and analysis of fractures, especially those involving the acetabulum and the sacrum. Analysis of complex fractures of the tibia involving its joint surfaces is of value in some cases.

**CT OF THE CHEST AND MEDIASTINUM**

**Indications**

A complete review of chest computed tomography in childhood is not possible here. General indications for CT examination of the chest and mediastinum are given in Table 4. In children with unilateral opaque hemithorax, CT accurately differentiates effusion, atelectasis, and tumor (Figure 3A, B). Usually, intrabronchial foreign bodies are detected by plain film examination but CT can be used in difficult cases as it very easily documents differential aeration. Moreover, on occasion, the actual intrabronchial or intratracheal foreign body can be identified even when it is non-opaque on conventional chest x-ray examination.9

Chest CT is the most sensitive means of detecting pulmonary metastases. CT is indicated if plain films are negative and if detection of metastatic disease would change staging or therapy. Most nodules thus discovered will prove to be malignant; however, in endemic areas granulomas are seen in significant numbers.10 Moreover, some nodules may persist following therapy without necessarily representing active malignant disease.11

CT has been useful in evaluating questionable findings seen on plain film examination as an alternative to conventional chest tomography. Sequestration can often be separated from other basilar densities. On
Figure 3. A) Twelve-year-old boy with clinical evidence of pneumonia. Frontal chest radiograph revealed an opaque, inferior right hemithorax. B) Contrast-enhanced CT scan through the opaque area. Pneumonia seen as an area of low density (arrows), is present in the right middle lobe (RML). A large pleural effusion (E) is noted. The right lower lobe (RLL) is atelectatic. (A—aorta, LV—left ventricle, RV—right ventricle).

continued from page 373
occassion, the feeding vessel from the abdominal aorta may be identified.12,13

The Mediastinum

Diagnosis of hilar and mediastinal adenopathy by computed tomography is difficult and differentiation of hilar nodes from vessels requires injection of contrast material.

The diagnosis of mediastinal masses in children is complicated by the presence of the thymus which in infants merges imperceptibly with the vascular structures of the mediastinum. In older children it can often be separated from the arch of the aorta by a fat plane. The usual appearance of the thymus in children
older than 5 years of age is that of a bi-lobed or arrowhead-shaped structure. In infants, of course, the gland is much larger and more variable in size and shape. The left lobe is often larger than the right. On computed tomography, its density in Hounsfied units approximates that of muscle tissue. The gland generally shows mild uniform enhancement and becomes clearly separable from the aorta and superior vena cava following contrast injection.

Thymomas are rare in children; even most children with myasthenia gravis do not have thymomas.

Anterior mediastinal masses more common in children include cystic hygroma, teratoma and lymphoma. Cystic hygromas either extend from the neck or present solely as a mediastinal mass. On contrast enhancement, septa can be seen surrounding an otherwise low-density mass. A teratoma can be diagnosed if fatty or calcific material is present in the mass.

Differentiation of lymphoma from normal thymus by computed tomography is usually relatively easy either because of non-uniform enhancement of lymphoma or a gross increase in size especially in the older child (Figure 4). There will be an occasional patient in whom borderline enlargement of the thymus is noted in a patient suspected of harboring a lymphoma. In these cases, diagnosis may only be established by surgery.

CT is of value in staging lymphoma. Disease thought to be limited to the neck can be shown to have mediastinal extension. Hilar node enlargement and extension into the lung parenchyma can be detected when not apparent on plain radiography. Complications of the disease such as airway compression and vascular compression syndromes are well shown by CT (Figure 4).[^15]

Mediastinal bronchogenic cysts are rounded or oval masses which often have Hounsfield numbers greater than zero, suggesting they are solid, but following enhancement their true avascular nature is revealed. They may be found in the middle or middle and posterior mediastinum.

Posterior mediastinal masses represent approximately 40% of all mediastinal masses seen in children. Of these, 95% are neurogenic lesions. CT with metrizamide is valuable to determine intraspinal extension of a paramedial mass, a finding which changes the operative approach.[^16] Neurogenic masses are often of relatively homogenous low density, above that of water but below that of muscle. Neuroblastoma and ganglioneuroblastoma may be calcified. Enteric cysts, sequestrations, chest wall lesions and aneurysms may also present in the posterior mediastinum.

CT has been found to contribute additional information from the plain chest x-ray in 82% of cases and to contribute to a substantial change in therapy in 65% of pediatric patients with mediastinal masses.[^17]

Though the airway is well-evaluated by high KV films, CT can provide additional information about possible airway compression or narrowing.[^15,18] CT diagnosis of post-tracheostomy subglottic stenosis has been shown to be useful.[^19] Compression of the airway by vascular rings is also well-detected by computed tomography.[^20] In infants with tracheoesophageal fistula, the side of the aortic arch can be established by CT.[^21]

**Table 5: Indications for Computed Tomography of the Abdomen in Children**

<table>
<thead>
<tr>
<th>1</th>
<th>Evaluation of abdominal masses</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Wilms' tumor</td>
</tr>
<tr>
<td>b</td>
<td>Neuroblastoma</td>
</tr>
<tr>
<td>c</td>
<td>Hepatic masses</td>
</tr>
<tr>
<td>d</td>
<td>Large abdominal and retroperitoneal masses</td>
</tr>
<tr>
<td>2</td>
<td>Abdominal trauma</td>
</tr>
<tr>
<td>3</td>
<td>Abdominal abscess</td>
</tr>
<tr>
<td>4</td>
<td>Abdominal lymphoma</td>
</tr>
<tr>
<td>5</td>
<td>Some hepatobiliary disorders</td>
</tr>
</tbody>
</table>

**CT of the Abdomen**

**Abdominal Masses**

Evaluation of the child with an abdominal mass has changed radically from 10 years ago. The combined inferior vena cavaography-intravenous pyelography approach has been replaced by ultrasound and angiography has largely been supplemented by CT. We recommend beginning the examination of a child who has a suspected mass by plain film radiography followed by ultrasound. If intussusception or other mass related
ferential diagnosis is nearly always possible (Figures 5 and 6). The CT features of the two lesions are outlined in Table 6.\textsuperscript{22}

CT is justified in these tumors because it provides greater accuracy of diagnosis and staging and is less expensive than a multiplicity of traditional examinations.

In addition to neuroblastoma, lesions included in the differential diagnosis of Wilms' tumor include renal lymphoma, Wilms' tumor variants, intrarenal hematoma and abscess.

Renal lymphoma is commonly bilateral. The kidneys may be of normal size or may show symmetric or asymmetric enlargement. Pre-vertebral perivascular adenopathy and vascular encasement are often present and the bone marrow density may be increased. At least 80% of the time, other evidence of lymphoma is apparent on the abdominal CT study. Renal lesions are isodense or of diminished density and usually are relatively homogeneous. Calcification is very uncommon.

Wilms' tumor variants include clear cell carcinoma, rhabdoid tumor, and fetal renal hamartoma. These are histologic and clinical variants without any gross pathologic or radiologic difference from the usual Wilms' tumor. The significance of these lesions is in their differing clinical behavior. The clear cell sarcoma is bone metastasizing and therefore a skeletal survey or radionuclide study is indicated. Rhabdoid tumors occur in the younger age group and are associated with CNS lesions which may be either secondary or primary lesions usually in the posterior fossa. Fetal renal hamartomas represent another variant also occurring under 1 year of age. These lesions are distinguished by their good prognosis, and the fact that they rarely, if ever, metastasize.

Variants which may be suspected on computed tomography include multilocular cystic nephroma and nephroblastomatosis. Multilocular cystic nephroma may be either benign or have tumor elements in its wall, a diagnosis which can only be established on histologic examination. On CT this lesion is characterized by well-formed enhancing septa.

Nephroblastomatosis may be a precursor of Wilms' tumor and is found in association with it. It may be seen either as an avascular rind or focal low-density lesions occurring in one or both kidneys.\textsuperscript{23}

An abnormal kidney is more easily injured and when hematuria is seen following relatively minor trauma, the possibility of an underlying abnormality should be considered. If an intrarenal hematoma is present, a follow-up CT examination may be necessary to exclude underlying pathology.

Acute pyelonephritis and acute focal bacterial nephritis (lobar nephronia) can cause focal renal enlargement suggesting a tumor mass but the CT appearance is different from that of Wilms' tumor with

\textit{continued on page 380}
peritoneal sarcomas may be difficult. Neuroblastoma usually shows calcification and some evidence of necrosis but if these features are lacking and the tumor has arisen from an extra-adrenal site, then accurate diagnosis may be impossible from the CT findings alone.

CT is especially valuable in neuroblastoma to detect intraspinal and prevertebral para-aortic extension. Discrete hepatic metastases are usually readily recognized. However, in Stage 4S neuroblastoma, diffuse hepatic involvement may be so extensive that the diagnosis is less obvious; usually in such cases the liver is grossly enlarged. Ultrasound and radionuclide liver scans are usually abnormal if the diagnosis remains in doubt.

Abdominal Abscesses

Abdominal abscesses may be diagnosed by conventional techniques, ultrasound, CT or radionuclide techniques depending on clinical indications. CT is especially valuable for localizing multiple loculations following perforated appendicitis and for detecting intra-abdominal abscesses associated with inflammatory bowel disease.24

Lesions are well-defined following contrast enhancement and may then be treated medically and followed by CT, or ultrasound, or drained surgically either percutaneously or at laparotomy. CT has been found to be the most accurate technique although ultrasound is the study of choice in the female pelvis and in the right subphrenic region. On computed tomography the most specific finding is the presence of gas in the abscess cavity; that has been present in approximately only 10% of our cases. Abscesses are often rounded, oval, or bi-convex masses of rather homogeneous low-density (15 to 30 Hounsfield units). A definable enhancing wall and low-density center are seen in most cases after contrast injection and suggest the lesion is drainable.

Abdominal Trauma

CT has made important contributions to the management of the child with abdominal trauma allowing accurate determination of extent of injury so that conservative therapy may be optimized.25,26 CT is recommended as the initial radiographic procedure in a child suspected of having serious intra-abdominal injury based on historical, clinical or laboratory findings if the child's clinical condition is stable.

Renal Trauma

Excretory urography underestimates the extent of renal injury in 15% to 30% of cases (Figure 7A, B). Renal lesions clearly shown by CT include subcapsular and perirenal hematomas, renal lacerations and intrarenal hematomas. More extensive renal fractures and shattered kidneys which may require surgery are also well seen on computed tomography. Avulsion of the renovascular pedicle is diagnosed by the lack of con-
Contrast enhancement of the kidneys. An advantage of CT in addition to the more accurate delineation of the renal injury is the ready detection of accompanying splenic or hepatic injuries. Multiple organ injury occurred in nearly one-fifth of the patients we have studied.\(^2\)

**Splenic Injury**

The most commonly injured intra-abdominal organ is the spleen but extensively damaged spleens may now be conserved by non-surgical methods in most cases. CT examination may reveal a simple or complex fracture or complete shattering of the spleen (Figure 8A, B). Fractures may be limited by the capsule or, if transcapsular, be associated with intraperitoneal blood. CT imaging of the spleen can be technically demanding in the injured child. Rib artifacts due to motion and nasogastric tube artifacts can degrade the image. The lesions usually heal without sequelae although a small scar may be evident.

Liver injuries are less common but are well-studied by CT (Figure 9). The injury may extend through the hepatic capsule and be associated with free intraperitoneal blood. The most common injury we have seen is slight diastasis along the falciform ligament. This is often a subtle finding. Following more extensive injury, large focal collections of low-density material may occur as the hematoma or laceration coalesces; it is difficult to be sure if this finding represents a hematoma or biloma. Technetium DIDA scan can be performed if necessary to differentiate between the two. Again, even in many of the most severe liver injuries, conservative management alone has been satisfactory.\(^2\) Complete healing without evidence of scarring occurs in all but the largest wounds; some residual calcification is not uncommon.

Duodenal hematomas are well seen on upper GI series but they are also readily diagnosed by CT scan. Narrowing of the contrast-filled lumen is observed and the hematoma itself can be visualized. Perforation of the duodenum associated with duodenal hematoma is more accurately diagnosed by CT than conventional studies. The pancreas, of course, also is well visualized by CT and post-traumatic pseudocysts easily diagnosed. This lesion is then followed by ultrasound and may be drained using ultrasound guidance if clinically indicated.

**HEPATOBLIARY DISORDERS**

The size, shape and density of the normal liver is well-studied by computed tomography. The density of the normal liver is about one to one-and-a-half times that of the normal spleen. Values significantly higher than the mean established for a particular scanner suggest deposition of iron in the liver as occurs in hemosiderosis. Decreased attenuation values are seen in cases of fatty infiltration of the liver; the infiltration
may be either focal or generalized. A value of one-third to one-half the normal range suggests fatty infiltration but may occasionally be seen in other liver disorders.

Other diffuse diseases of the liver such as cirrhosis and hepatitis produce no constant abnormalities in CT values.

Focal abnormalities in the liver are produced by primary or secondary tumors, the latter being more common in children. Metastatic lesions are most often seen as small, rounded, discrete, low-density masses but can be diffused particularly in Stage 4 neuroblastoma.

Because of its superior anatomic detail, CT has been the most accurate examination for evaluation of metastatic disease although radionuclide scan and ultrasound studies are also useful in selected circumstances.

Primary liver tumors seen in pediatric patients include hepatoblastoma, hepatocarcinoma, and benign liver tumors such as hemangioma and hamartoma. Space precludes discussion of the various CT manifestations of these neoplasms but CT has been used successfully in diagnosis and staging of these lesions.27 Large neuroblastomas or Wilms' tumors may extend into the liver from below and suggest primary liver tumors, although, as the tumor is followed inferiorly one can usually determine its true site of origin.

Hepatic tumors are one remaining instance where the surgeon may still require a pre-operative angiogram to serve as a "roadmap." CT, however, appears to be quite successful in differentiating tumors of the right lobe from those of the left lobe.

CT depicts the biliary system well and small degrees of ductal dilatation can be recognized after contrast enhancement. However, radionuclide techniques using biliary tract labelling agents provide physiologic information regarding function, and ultrasound studies can depict anatomy so that CT is reserved for those cases in which the diagnosis is not clear from examination using these two modalities.

Abdominal Lymphoma

A properly performed, contrast-enhanced computed tomographic examination of the abdomen allows confident diagnosis of enlarged retroperitoneal lymph nodes as well as detection of masses in the mesentry, liver, kidney, and other organs. Many institutions are now using abdominal computed tomography for staging of lymphoma. False-negative studies will occur when the lymph nodes are replaced by tumor without being enlarged. This virtually never occurs in non-Hodgkin's lymphoma but has been seen in our experience about 5% of the time in Hodgkin's lymphoma. Microscopic invasion of the spleen is a diagnosis which can be established only by staging laparotomy and splenectomy although large intrasplenic deposits can be seen on contrast-enhanced computed tomography. Our current practice in children with lymphoma is to use computed tomography as the preferred radiologic staging examination. If computed tomography is positive, biopsy may be necessary for histologic confirmation. If CT is negative and the patient is known to have Hodgkin's lymphoma, a staging laparotomy and splenectomy is indicated.

SUMMARY

CT of the body has had major impact in the diagnosis of trauma, infection, and neoplasms in children. Properly used, it is a safe, accurate, and cost-effective imaging procedure which can replace many previously required conventional imaging studies.

REFERENCES