Chapter 2
Medical Imaging Needs in a Rural Health Center from a Clinical Point of View

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Abstract In a rural health center, certain health conditions may benefit from simple imaging technologies such as conventional radiography and ultrasound. Radiological and ultrasound findings can help diagnosing: Chest illnesses (e.g., viral and bacterial infections such as tuberculosis), trauma, degenerative diseases of the musculoskeletal system, acute abdominal pain, diarrhea, blunt abdominal trauma, kidney stones, pregnancy, and gynecological problems. Specific protocols should not be rigid and they should always be a complement of the clinical examination and other tests, such as laboratory exams, if available. Even though a radiologist may not be present, a general practitioner should be available in case a health problem arises during the examination. These practitioners, as well as imaging technologists and/or nurses working in the center, should have minimal medical and technical knowledge of conventional X-ray imaging and basic ultrasound, to decide whether the patient can be managed locally or referred to a higher health care level.

Keywords Infections · Trauma · Chronic diseases · Pregnancy · Rural health center

2.1 Introduction

Health systems are structured by health care levels according to the complexity of the health problems faced in each one of them. Those situations that affect health in a community determine the demand for services and their relative frequency, and they affect the growing complexity of the resources that need to be mobilized in the health care process. It is thus possible to relate the concept of levels of care to the

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geographic location of health care establishments or units, in order to systematize the supply of services according to the size, characteristics, and needs (or demands) of different population groups [1].

The general practitioner working in rural primary health care should contemplate the use of images in medical diagnosis as a support to clinical findings. Three basic requirements may be considered, i.e.

- Availability of technology
- Risk-benefit
- Cost-benefit.

These considerations will result in the rational use of technology including the use of adequate examination protocols. Imaging studies are a complement of clinical reasoning, which in turn is derived from the slow and painstaking observation of the patient.

The general practitioner working in a rural health area should have at least minimal medical knowledge of conventional X-ray imaging and basic ultrasound. Training may be obtained through graduate or postgraduate courses. Similarly, imaging technologists and/or nurses, who work in the same health care level, should receive training regarding the right acquisition and protocol management of the images. Training issues for the technical staff are addressed in Chap. 6. Even though a radiologist may not be present, a general practitioner should be available should a health problem arise during the examination.

In this regard, a mobile phone may facilitate an easy exchange of information among the medical staff. This is another way of implementing telemedicine. Consultations may be required especially in cases of dubious diagnoses. The possibility of photographing images of enough quality to provide diagnostic information should be assessed. Telecommunication issues are addressed in Chap. 7 . We intend in this chapter to develop a group of health conditions that may benefit from imaging using simple technology—conventional radiography and ultrasound—which can be available to general practitioners working in rural areas. Specific protocols should not be rigid and they should always be a complement of the clinical examination and other tests, such as laboratory exams, if available.

Imaging is not only useful for diagnosis, but also for patient follow up. Figure 2.1 shows that relationship.

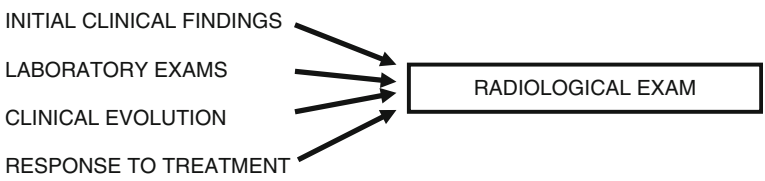

Fig. 2.1 Relationship between radiological exam and another's clinical points

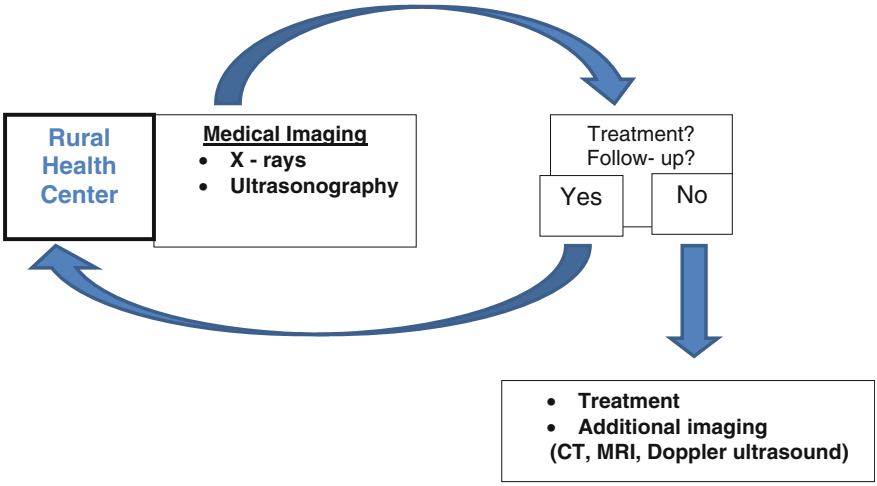

Fig. 2.2 Flow diagram of patient management

Depending on the radiological findings, patients may be treated at the rural health center or derived to a secondary or tertiary health care level. Figure 2.2 shows a flow diagram of patient management.

The health conditions that may require imaging in a rural health center are

1. Chest diseases: viral and bacterial infections such as tuberculosis
2. Trauma
3. Degenerative diseases of the musculoskeletal system
4. Acute abdominal pain, diarrhea, blunt abdominal trauma
5. Kidney stones
6. Pregnancy
7. Gynecological problems.

2.2 Chest Diseases

Chest X-rays may be indicated in patients with respiratory problems such as colds, shortness of breath, cough, and associated fever especially during cold and/or humid months. Often the anxiety generated in patients with these symptoms results in excessive chest radiographs without clinical examinations.

2.2.1 Viral Lower Respiratory Infections (Common Cold)

When the viral infections, such as influenza and parainfluenza, after several days of fever, do not wear off with medication and, on auscultation, there are crackles or rales, there may be suspicion of viral/bacterial pneumonia or bronchopneumonia as a potential complication of the original infection. This is a frequent indication for a posteroanterior radiograph of the chest. Lateral projections are usually not necessary.

Radiological Findings:

The spectrum of images in viral respiratory infections varies with age. We can find [2]

1. An increase of the pulmonary radiotransparency (hypertransparency) as in cases of bronchiolitis in children.
2. Enlargement of the basal hilum pulmonary branches caused by peribronchovascular inflammation (commonly found in children and adults).

Cases in which the viral symptoms get complicated, lobar, or segmental radio-opacities of the lung may appear with the bronchogram sign typical of pneumonia (see Fig. 2.3). In pediatric cases, we may find opacity in masses, due to atelectasis produced by mucous plugs that lead to bronchial obstruction without the bronchogram sign. These cases can be treated in primary health care, without having to go to a higher level, by means of antibiotic therapy on an outpatient basis. It is important to monitor the patient's clinical evolution and response to treatment and to remember that the initial radiological findings disappear weeks after clinical improvement [2].

It is always important to follow-up previously diagnosed chronic lung diseases.

2.2.2 Bronchiectasis

Congenital or acquired bronchial dilatations are common reasons for recurrent respiratory infections. If there is any suspicion of a bronchiectasis re-infection, as is the case of Cartagener and Monier Kuhn Syndromes; one can perform a chest radiograph (posteroanterior projection) and treat the infection locally without sending the patient to another health care level [3].

Radiological Findings:

1. Normal radiography (the study is negative despite the existence of bronchiectasis without infection).
2. Depending on the shape, number, and location of bronchiectasis, we may find an opaque image, extending from the mediastinum to the diaphragm, with radiotransparent images inside (infected bronchiectasis).
3. Radiotransparent images with the shape of pigeon nests, preferably located in the lung apices; some of these images have fluid levels inside.

Fig. 2.3 Pneumonia of the right middle pulmonary lobe as a complication of a lower respiratory tract viral infection

2.2.3 Pulmonary Emphysema (Bullous)

Sometimes, in our consultations we have elderly or senior patients with an inveterate habit of smoking, who complain of respiratory distress. During auscultation, we detect hoarse and sibilant rales. The radiograph of the chest (posteroanterior projection) can be useful to determine if this patient has a respiratory failure that can lead to a cardiovascular complication (see Fig. 2.4).

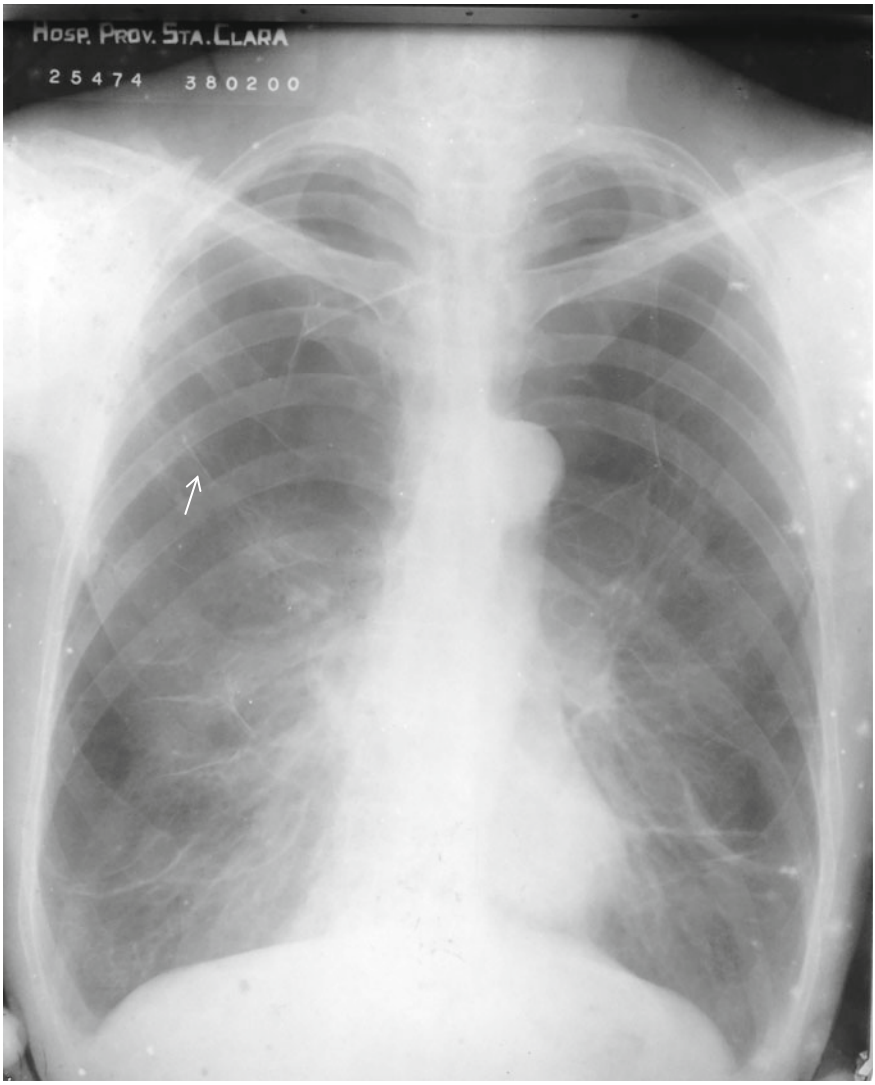

Fig. 2.4 Bullous pulmonary emphysema in both upper lobes. Focal hyper transparency, with thin and incomplete walls as seen in the bullae (*white arrow*)

Radiological Findings:

Increased of the localized pulmonary hypertransparency, with a thin and discontinuous wall without pulmonary reticulum (emphysematous bullae), with or without indirect signs that depend on the extent of the emphysema and are independent of the patient biotype [3].

(a) Horizontality of the costal arches.
(b) Widening of intercostal spaces.

(c) Descent of hemidiaphragms.
(d) A heart with the shape of a drop.

2.2.4 *Pneumothorax*

A patient with sudden chest pain and shortness of breath can go to a health center for help, and after physical examination is performed, we may suspect the diagnosis of air within the pleural cavity; which can be confirmed by a chest radiograph (posteroanterior projection) (see Fig. 2.5).

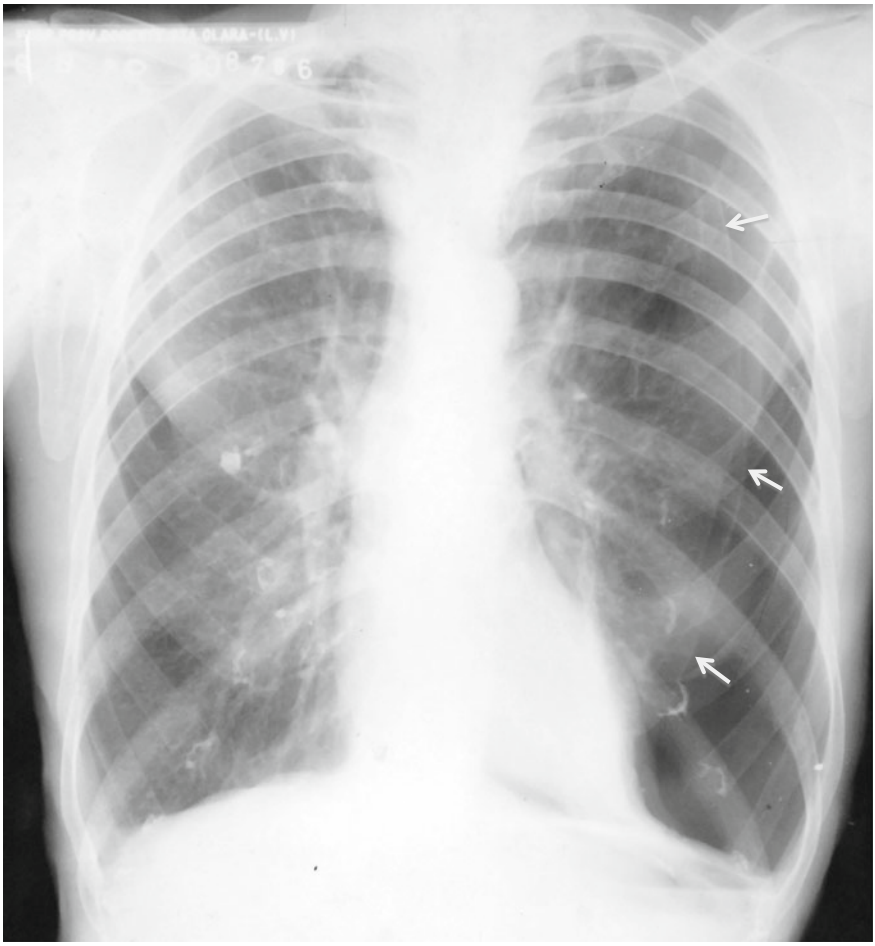

Fig. 2.5 Right pneumothorax of 25 % presence of air within the left pleural cavity, without pulmonary reticulum and pleural line (*white arrows*)

Radiological findings:

1. Hypertransparency with absent peripheral lung markings.
2. Fine white line of the visceral pleura.

If the pneumothorax is large and there is a mediastinal shift away from the side of the injury, it is considered to be under tension. If left undetected, this can be rapidly fatal.

The association of blood with pneumothorax after any chest trauma, the finding of hypertransparent images mentioned before, is associated with blood collection inferiorly in the pleural spaces of the lung to form a subpulmonary opaque image. Whenever this condition occurs, the patient must be sent to a second level of health care.

2.2.5 Tuberculosis (TB)

When an outbreak of respiratory signs and symptoms suspicious of tuberculosis reactivation occurs, the chest radiograph (postero-anterior projection) is useful to identify the existence of new tuberculosis activity and compare it to previous radiographic studies of the patient [4].

Radiological Findings:

1. Analyze how TB was cured in the previous images, assessing if there were calcifications, fibrous tracts, and apical sclerosis; if there was a cavern which no longer exists, etc.
2. Signs of tubercular activity, such as pleural effusion (discussed below). Tuberculous effusions may have septa with loculations.
3. Cavity with air fluid level.
4. Bronchopleural and tracheobronchial fistulas.

2.2.6 Pleural Effusion

It can be found in a routine chest X-ray without any symptoms. There may be actually 250 ml of fluid present before it is detected radiologically [5].

Radiological findings:

1. An opaque image producing blurring of the costophrenic angle. This opacity may be found in shadows and masses. When the density is very high, the costal arches cannot be seen. In these cases, if there is any doubt, the thoracic ultrasound can be useful for the diagnostic difference between pleural effusion and thickening. The echolucent image, with or without septa, would confirm the diagnosis of fluid (see Fig. 2.6); the echogenic image would indicate pleural thickening.

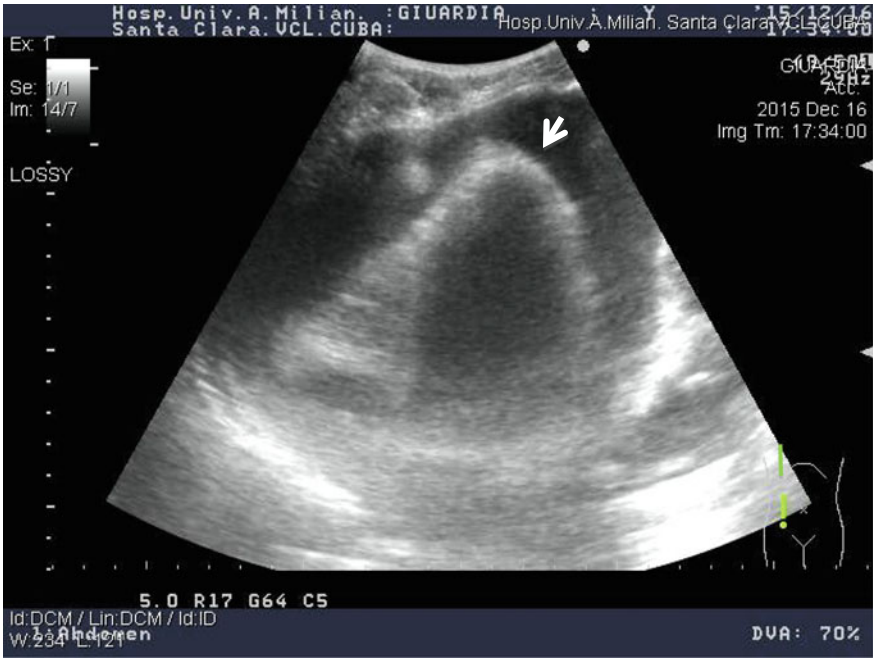

Fig. 2.6 Thoracic ultrasonography (coronal plane) of the right lung base, with echolucent image and echogenic band consistent with pleural effusion and septum due to empyema (*white arrow*)

When there is little pleural effusion, a decubitus chest radiograph or chest ultrasonography is needed to confirm it. Depending on the clinical findings, it is not necessary to send the patient to another health care level, for example, if the patient exhibits little pleural effusion associated to any viral infections.

2.3 Musculoskeletal Conditions

2.3.1 Trauma

Bone trauma is a frequent reason for immediate consultation with the doctor. Examples are minor accidents, with patients suffering from pain in the traumatic area or if there is suspicion of fractures in hands or feet.

When the general practitioner notes swelling, changes in skin color, also difficulty moving the injured anatomical area, there may be a doubt of a possible fracture. In these cases, a conventional radiograph of the affected bone structure must be done in at least two different positions (anteroposterior, lateral, or oblique

projection). When the diagnosis is unclear, we recommend making the comparative radiograph with the contralateral structure.

Radiological Findings:

- **Radiotransparent line fracture**: It is very important to analyze the relationship between the fractured fragments of the bone and the form of the fracture line to see if it is possible to solve the problem in the rural health center, without sending the patient to another health care level.

Kids' bones are more likely to bend than break completely because they are softer. Fracture types that are more common in children include

- **Buckle or torus fracture**: one side of the bone bends, raising a little buckle, without breaking the other side
- **Greenstick fracture**: a partial fracture in which one side of the bone is broken and the other side bends (this fracture resembles what would happen if you tried to break a green stick).

Mature bones are more likely to break completely. A stronger force will also result in a complete fracture of younger bones [6].

A complete fracture may be a

- **closed fracture**: a fracture that does not break the skin
- **open (or compound) fracture**: a fracture in which the ends of the broken bone break through the skin (these have an increased risk of infection)
- **non-displaced fracture**: a fracture in which the pieces on either side of the break line up
- **displaced fracture**: a fracture in which the pieces on either side of the break are out of line (which might require surgery to make sure the bones are properly aligned before casting).

Other common fracture terms include

- **hairline fracture**: a thin break in the bone
- **single fracture**: the bone is broken in one place
- **segmental**: the bone is broken in two or more places in the same bone
- **comminute fracture**: the bone is broken into more than two pieces or crushed.

Always the fractures must be treated in a second heath care level by the traumatologists; uncomplicated fractures can be followed-up in rural health centers.

To take a plain film with at least two views (Antero posterior and lateral or oblique views) could be useful as a first step in the management of any trauma, as long as the clinical condition of the patient allows it (see Fig. 2.7a, b).

It is important to analyze the evolution of the consolidation of the fracture. To do that, conventional X-rays are very useful in rural areas. Table 2.1 shows the time a fracture in adult tubular bones takes to consolidate.

To determine the prognosis and proper treatment of fractures, it is important to know their classification. Fractures can be treated conservatively using a cast or

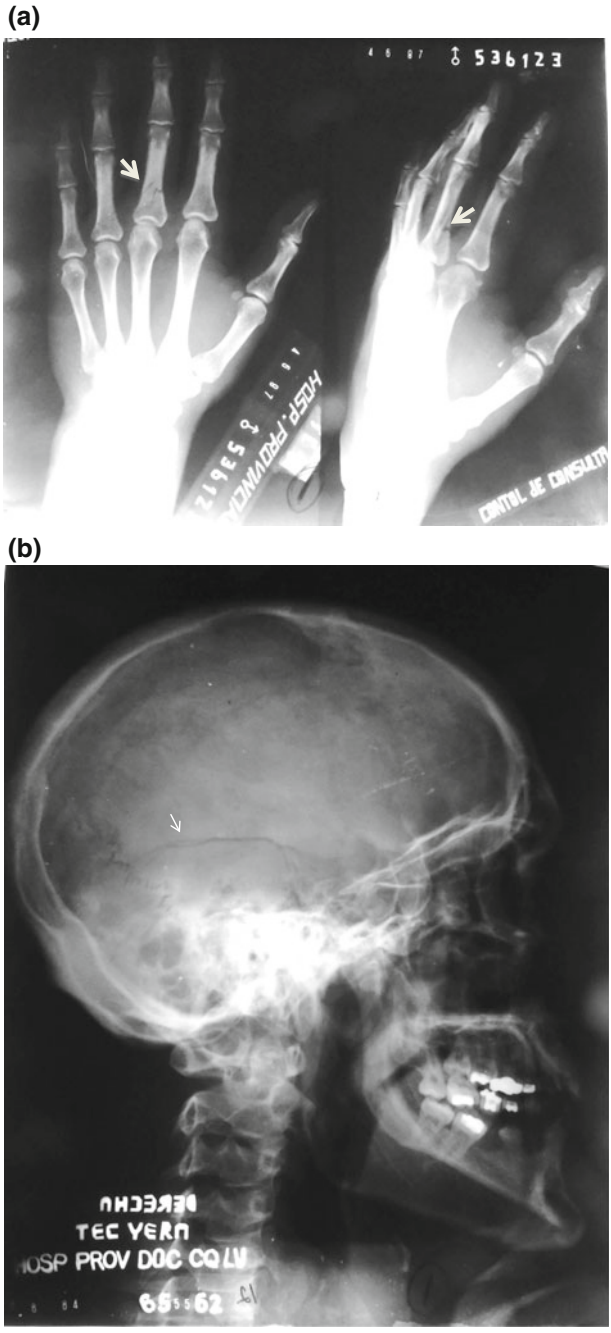

Fig. 2.7 **a** Oblique transparent line of fracture in the third proximal phalange of the left hand, as it can be seen in AP and oblique views (*white arrows*). **b** Lateral skull projection with temporal line fracture (*white arrow*)

Table 2.1 Time of fracture consolidation in tubular bones in adults [6]

	Upper extremity (weeks)	Lower extremity (weeks)
Early callus	2–3	2–3
Late consolidation	6–8	12–16

with the use of surgical internal or external fixation. The latter would require another level of assistance and not the rural health center.

If the fracture is incomplete, such as the greenstick fracture, reduction is usually easy and recovery is usually quick. On the contrary, compression fractures are rarely completely reducible.

The minor head trauma without neurological signs is of particular importance. From our point of view, a conventional skull radiograph (with anteroposterior, lateral, and Towne's projections) could be useful to assess any small fracture, together with the clinical observation that can be done within the first hours after the trauma (see Fig. 2.7b).

2.3.2 Degenerative Osteoarthritis of Spine

Low back pain is one of the most common causes of physicians' visits—with an enormous socioeconomic burden—as a result of degenerative processes such as osteoarthritis (see Fig. 2.8).

The spine is the most important and crippling area of the human anatomy that is affected by degenerative conditions, followed by hips and hands.

Lumbar and cervical pain, without any other symptoms, are the most common clinical conditions in patients complaining of increased pain early in the morning after waking up and whose symptoms improve during the day after the start of any daily physical activity [7].

The management of low back pain in primary heath care should be firm about not recommending radiography of the lumbar spine in patients with low back pain in the absence of indicators for serious spinal disease, even if the pain has persisted for six weeks. Unfortunately, though, patients undergoing radiography are more satisfied with the care they receive. The challenge for the primary care physician is to increase the satisfaction without recurring to radiography [8, 9].

The general practitioner may request certain exams to aid in the diagnosis of osteoarthritis of the spine. These tests include

- X-rays to look for bone damage, bone spurs, and loss of cartilage. However, X-rays are not able to show early damage to cartilage.
- Blood tests, mainly to look for rheumatoid arthritis, but also to exclude other diseases (not in rural health centers).

Fig. 2.8 Cervical degenerative changes, with anterior osteophytes and narrowing of the intervertebral spaces as indirect signs of disc degeneration (*black arrows*)

Radiological findings:

1. Low bone density (high bone radiotransparency, cortical thinning, and wide medullar channel)
2. Vertebral osteophytes and facet joint osteoarthritis
3. Disc space narrowing (indirect sign of intervertebral disc disease)
4. Subcondral sclerosis
5. Vertebral fracture by osteoporosis can be found sometimes in women in their third decade of life.

The patients with minor symptoms could be treated in rural health centers. If the symptoms cripple the patient, it is necessary to ask for a second opinion in other health care level.

2.4 Acute Abdominal Pain

Symptoms of acute abdominal pain could be a common problem and we need to pay immediate attention to them and act quickly. The medical questioning could guide us in the images to confirm our clinical diagnosis.

2.4.1 Right Hypochondria Pain

After rich fat meals, the symptoms in the right hypochondria are often a reason to visit the health care center looking for a general practitioner´s opinion.

Ultrasonography is a wonderful medical imaging tool to evaluate these symptoms. During the ultrasound exploration, the presence of gallstones could be the cause of pain exacerbation. Acute cholecystitis due to stones (see Fig. 2.9), would look like [10]

1. Echogenic images with acoustic shadow
2. Wall bladder more than 3 mm thick
3. In acute inflammation it is possible to see an echolucent fine line surrounding the wall, due to edema
4. Positive ultrasonography Murphy sign.

It is very important to recognize the normal anatomy of the gallbladder by ultrasound (see Table 2.2) to assess properly any ultrasonography pathology. Do not forget to check at the same time the pancreas and the biliary ducts, analyzing the size and changes in the echogenicity by pancreatitis as a complication of the presence of any stone in the main biliary ducts. In this case, the patient must be seen by a surgeon in another health care level, not in rural centers, for surgical or non-surgical treatment.

Fig. 2.9 Acute cholecystitis. Echogenic image (gallbladder stone) with acoustic shadow (*white arrow*) and wall bladder thickness of 5 mm (*black arrow*)

Table 2.2 Gallbladder normal ultrasonography anatomy

Feature	Description
Location	Inferior to interlobar fissure
	Between left and right lobes
	Gallbladder can be used as a separating landmark for the lobes
Size	<4 cm transverse plane
	<10 cm longitudinal plane
Wall thickness	<3 mm (upper limit = 3 mm)
Lumen	Anechoic
Common variants	Phrygian cap (fundus folds on itself)
	Junctional fold in the neck
	Gallbladder may be intrahepatic just above the interlobar fissure

In a routine abdominal ultrasound examination, the liver is the biggest gland in the abdominal cavity, and we should never forget to view it in different ultrasonography planes [11].

Before reporting any hepatic problem it is important to recognize the normal anatomy by ultrasound (see Table 2.3).

Table 2.3 Liver ultrasonography anatomy

Features	Appearance
Size	<15 cm (normal upper midclavicular length limits = 13–17 cm)
	The liver never overtakes the costal rim
Echogenicity	≥right kidney
	<pancreas
	<spleen
Parenchyma	Homogeneous
Surface	Smooth

2.4.2 Acute Abdominal Distention with or Without Pain

The air distention of small or large bowels in elderly people with previous history of large periods of lying in bed, as well as constipation, could be a motive to visit the health center. Some times, some medications improve the patient's symptoms without the necessity to transfer him/her to another health care level.

Acute obstruction of the small or large intestine is an emergency all over the world and the patients must always be sent to another health care level, where they can be properly treated, but in the meantime, a plain X-ray will allow to make the diagnosis [12].

The recommended plain abdominal X ray (conventional views) are

1. Chest X-ray (Posteroanterior projection): looking for pneumoperitoneum, or any chest pathology that simulates acute abdominal picture.
2. Supine position (Posteroanterior projection): This image allows to analyze the abnormal air patterns of the bowels.
3. Standing views (Posteroanterior projection) looking for air fluid levels, as an occlusive picture.
4. Lateral view of the rectum: looking for air in it.

2.4.2.1 Paralytic Ileus

In a dynamic ileus, the lumen of the bowel remains patent but the loss of propulsive power and tone lead to focal or general distention with accumulation of gas and fluid within the paralyzed loops.

Radiologically this results in generalized gas and fluid distention, with gas predominance, involving large and small bowels and the stomach with air in the projection of the rectum [12].

Paralytic Ileus sometimes is associated to peritonitis, like appendicitis; for these cases another health care level is necessary.

Fig. 2.10 Small and large bowel distention in a patient with paralytic ileus

The simple or complicated obstruction of the intestine cannot be treated in rural centers. Therefore, it is necessary to immediately evacuate the patient to another health care level where there is a surgeon for evaluation and treatment (Fig. 2.10).

Radiological Findings (In cases the patient stays long time in bed)

1. Enlargement of the large, small or both bowels loops, with air predominance and little fluid levels
2. Not significant thickness of bowel walls

3. Feces in the colon projection, including the rectum in lateral view.

Some decompressive maneuver can help in these cases, without transferring the patient to another health care level.

2.4.3 Diarrhea

For the patients with common diarrhea it is not necessary to use any medical images. The results of the clinical examination and previous history during the exam are the main factors that affect treatment decisions. Only in chronic diarrheal syndrome, the abdominal ultrasound is useful by looking for any gallbladder disease or liver pathology as focal echogenic lesions that may indicate metastasis or in cases where the general practitioner found a mass during palpation.

The procedures with barium are not necessary in rural areas. If the doctor has a clinical idea of any problems like tumors, ulcer, polyps, etc., for example, if the patient has heavy rectal bleeding, the endoscopy is the right procedure to do. However, that should be done in another health care level, in some cases with biopsy of the lesions.

Figure 2.11 shows an image of a barium enema.

2.4.4 Right Iliac Fossa Pain

If the practitioner suspects during the clinical examination the possibility of appendicitis, the abdominal ultrasound with full bladder as an acoustic window to make the exploration, is a right procedure to see any ultrasonographic findings such as

1. Enlargement of the appendix in a transverse plane that looks like a dartboard
2. Complex image surrounding the appendix or fluid around it
3. Blumberg ultrasonographic sign.

2.4.5 Splenomegaly

It is not a condition that the patient can be aware of, but sometimes it is an incidental finding during a routine ultrasonography exploration [13].

Splenomegaly exists when the measurement values exceed the normal limits in at least two planes (more than 14 cm in longitudinal measuring, overtaking the inferior pole of the left kidney and 6 cm in transverse diameter; see normal spleen anatomy (see Table 2.4).

Fig. 2.11 Problems like tumors (*white arrow*) can be seen in a barium enema, a procedure done at a secondary or tertiary health care level

Table 2.4 Spleen ultrasonography anatomy

Feature	Appearance
Size	≤14 cm; ≤6 cm thick
Echogenicity	>left kidney; >liver; >/<pancreas
Echotexture	Homogeneous
Surface	Smooth
Shape	Crescentic

As a clinical examination does not provide an adequate assessment of splenic enlargement, echographic size assessment plays an important role in the diagnosis and follow-up of these patients.

The numerous causes of splenomegaly range from infections and immunologic disorders, hematological diseases and benign or malignant infiltration of the spleen. It may appear in association or without focal hypoechogenic or echogenic nodular lesions.

- Infections usually lead to only moderate enlargement with the exception of tropical parasite infections; the symptoms may gradually disappear after the acute infection resolves.
- Cirrhosis of the liver and portal hypertension is also common causes of small splenomegaly.
- Splenic enlargement alone is an unreliable sign of diffuse myelo or lympho-proliferative infiltration.

Spleen enlargement always requires to be evaluated by a second health care level physician, who should identify the possible cause and apply the protocol for patient follow up; sometimes it is a necessary evaluation by a hematologist.

2.5 Urinary Tract Imaging

A probe of 3.5 MHz is generally used to do an ultrasound examination of the adult kidney. The kidneys are scanned in all planes. The patient should be placed in the supine or decubitus position.

Indications:

- Flank pain
- Hematuria
- Elevation of blood urea
- Acute renal failure
- Acute or chronic pyelonephritis and glomerulonephritis
- Diabetic nephropathy.

The renal capsule cannot be distinguished from the renal parenchyma, which is less reflective than the liver and spleen. The echogenic center of the kidney corresponds to the renal sinus, a space within the renal tissue; it contains the renal pelvis, the renal vessels, connective tissues, and fat.

2.5.1 Kidney Stones

The prevalence and incidence of nephrolithiasis is reported to be increasing across the world. Changes in dietary practices may be a key driving force. In addition, global warming may influence these trends [1].

More men form stones than women. The sex ratios range from 2.5:1 in Japan to 1.15:1 in Iran [14, 15]. However, there are age ranges in some countries where this ratio is reversed. Data comparing stone disease differences between races within one country were available only for the United States [16]. Prevalence and incidence rates were highest for whites, followed by Hispanics, African Americans, and Asians.

Three studies published between 1991 and 2003 examined asymptomatic stone prevalence rates by performing ultrasonography on randomly selected subjects [17, 18].

Concretions within the renal pelvis typically appear as circumscribed changes. A stone is seen as a hyperechogenic focus with acoustic shadowing. Calculi which do not cause urinary tract obstruction and corresponding symptoms (colic, calyceal ecstasies) are generally situated in the zone of acoustic shadowing outside the central echo complex, and they are often incidental findings. Calculi of the order of 3 mm can be visualized under favorable conditions. Hydronephrosis is an important sign of possible concretions. The chemical composition of the renal calculi does not play an important role in echography, as opposed to radiology. Staghorn calculi are characterized by dense echoes from all calyces, which unite to form band-shaped, highly reflective zones in the renal pelvis (see Fig. 2.12).

Patients with kidney stones measuring less than 3 mm and without hydronephrosis or fever do not have to be sent to another level of health care. Such patients will need treatment for pain management and some medications to evacuate the stone. Follow up can be done by ultrasonography after few days, always when the clinical status of the patient allows it. However, if the patient has a stone in the urinary tract more than 3 or 5 mm on any side, and presents hydronephrosis and fever, it is necessary to send him/her to another level of health care. The stone could have resulted from complications due to a urinary infection, secondary to the obstruction, and the patient needs to be evaluated for future treatments, perhaps using minimal access procedures.

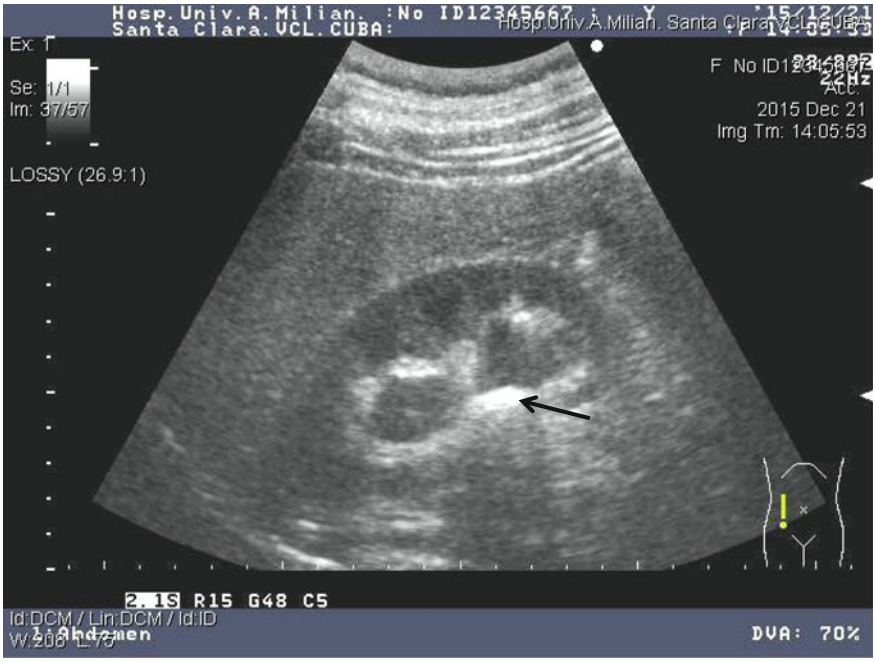

Fig. 2.12 Echogenic image with acoustic shadow in the renal pelvis of the right kidney and hydronephrosis, consistent with kidney stone (*black arrow*) and obstructive hydronephrosis

2.6 Pregnancy

2.6.1 Gestational Age and Fetal Functions

Ultrasonography is very useful for diagnostic evaluation and follow-up of pregnant patients if a proper transducer is used; intrauterine structures can be detected with sizes from 1 to 3 mm.

Ultrasound findings:

6th week: To assess the embryonic development, it is possible to evaluate the chorionic cavity (1–5 mm) on the 4th week of pregnancy after the last period (see Fig. 2.13).

First trimester: in addition to detecting the existence and location (ectopic or normal) of pregnancy, ultrasonography is performed primarily to assess the viability of the fetus (movement, cardiac action) and to determine the number of embryos (multiple pregnancy), and the gestational age and morphology (anomalies) of the fetus (towards the end of the first trimester). Ultrasound measurements are useful for determining the gestation age of the fetus or, if the gestational age is known, for assessing the development of the embryo and fetus [19].

Fig. 2.13 5-week pregnancy, where the gestational sac can be measured

These measurements include

≤9th week—diameter of the chorionic cavity.
6th–12th week—crown to coccyx length (CRL). See Fig. 2.14.
≥9th week—biparietal diameters (BPD) measured from the outer skull table to the inner skull table (see Fig. 2.15) and for the femoral length see (see Fig. 2.16).

Not only the gestation age can be estimated from measurements in the ultrasound images; ultrasound is also very useful to detect disorders that occur in early pregnancy. In the second and third trimesters, fetal development, and morphological anomalies can be assessed and detected with high reliability [20]; see Figs. 2.17, 2.18, 2.19 and 2.20 [2–4].

Intrauterine growth can be monitored using a normal curve with comparison data. The weight of the fetus can be calculated from multiple (2 or 4) measurements using empirical formulas. This provides a means of early detection of fetal retardation and hypertrophy [20].

Ultrasound can also be used to assess fetal function, e.g., for observation of fetal movement and behavioral patterns. Ultrasound monitoring of the placenta and umbilical cord is also an important part of pregnancy follow-up (location and structure; growth development; such complication as abruption placentae, hydrops, and tumors). Although fetal echocardiography must be done by specialists trained in other level of health care, it is possible to identify, at least, the cross of the heart (in four chambers view) see Fig. 2.21 [14]. This allows to determine a cardiac septum defect and also to see enlargements of cardiac cavities or any small congenital intracardiac tumor.

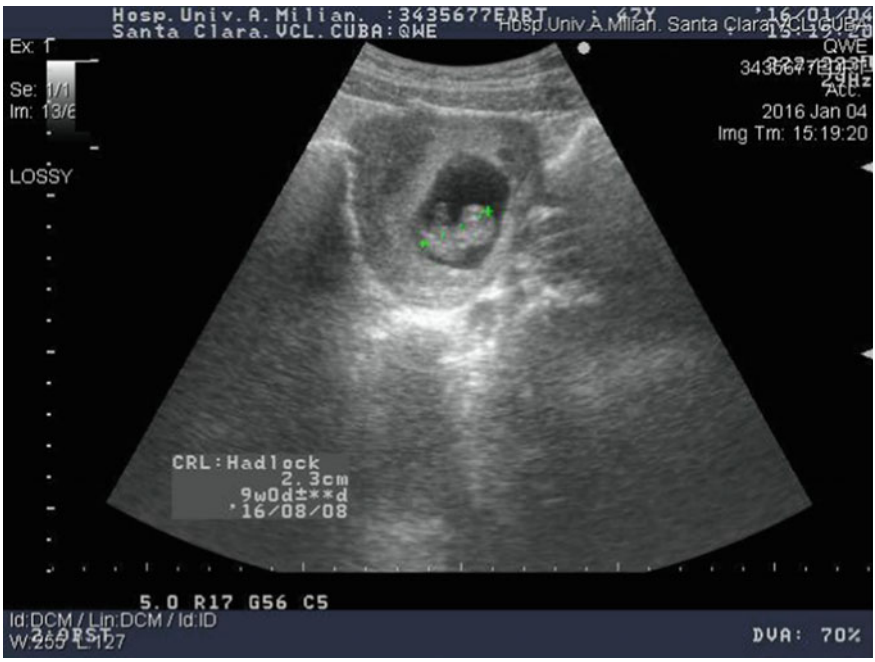

Fig. 2.14 9-week fetus with a CRL of 2.3 cm

Fig. 2.15 Biparietal diameters can be measured from the outer skull table to the inner skull table

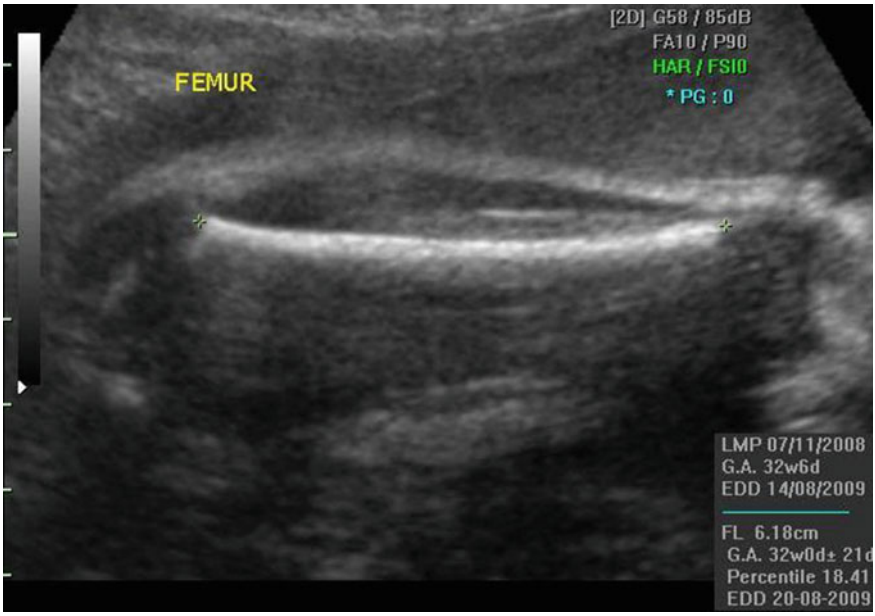

Fig. 2.16 The fetal femoral length can also be measured in an ultrasound image

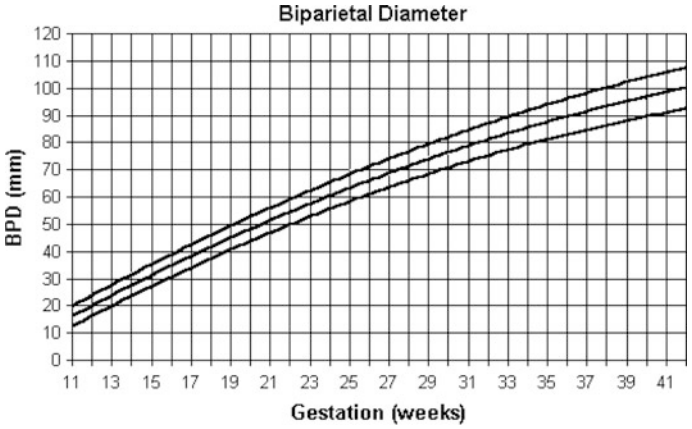

Fig. 2.17 Variation of BPD versus gestation

The amniotic fluid can also be assessed by ultrasound as an important part of antepartum fetal surveillance. It may detect problems with the fetus, placenta, or another condition. It is important at least to know a simple method to evaluate it; the amniotic fluid index (AFI), or four-quadrant technique, has been suggested [21, 22].

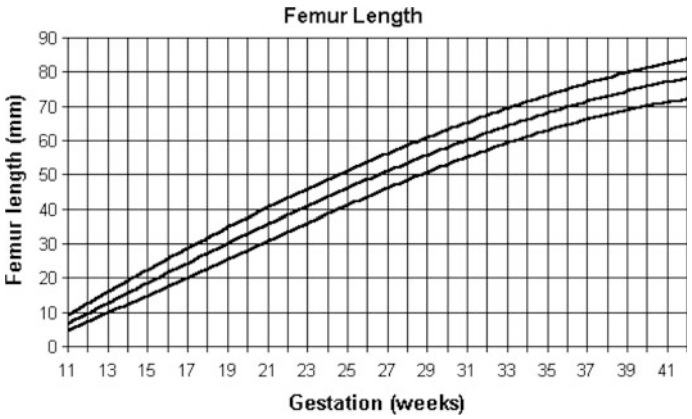

Fig. 2.18 Variation of fetal femur length versus gestation

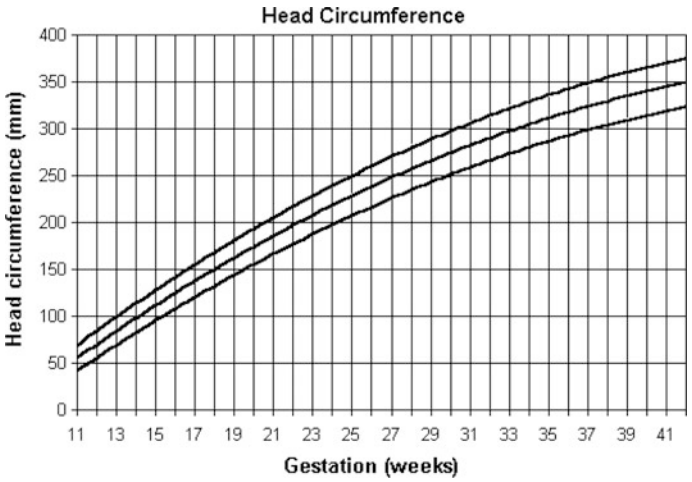

Fig. 2.19 Variation of fetal head circumference versus gestation

1. All amniotic fluid studies can be done using a real-time linear array B-scan.
2. Amniotic fluid index (AFI) measurement with the modified four-quadrant technique (largest vertical pocket). In the third trimester, the AFI index is 16.0 ± 4.8 cm.
   (a) From 13 weeks' gestation, the AFI grows progressively until 26 weeks.
   (b) From then to 38 weeks, the AFI measurements demonstrate little variation.
   (c) After 38 weeks, the AFI appears to decline gradually.
3. High-risk pregnancies with an amniotic fluid index of ≤5 cm appear to carry intrapartum complication rates similar to those of similar high-risk pregnancies with an amniotic fluid index of >5 cm [23].

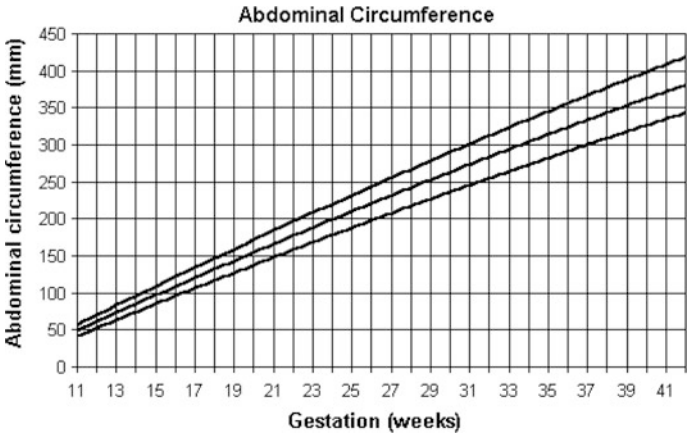

Fig. 2.20 Variation of fetal abdominal circumference versus gestation

Fig. 2.21 Normal view of the four fetal cardiac chambers

Table 2.5 Normal and abnormal values of amniotic fluids levels (AFL)

Methods to measure	Normal (cm)	Polyhydramnios (cm)	Doubtful (cm)	Olygoamnios (cm)
AFI	8.1–24	>24	5.1–8	<5

Table 2.5 lists normal and abnormal amniotic fluid levels.

2.6.2 Pregnancy Management

Pregnancy assessment by ultrasound is necessary to have the basic tools to know when any problems may appear in a pregnant woman. It is important, however, never to forget the relation between the clinical symptoms and the ultrasound findings. For example, bleeding in a pregnant woman is not the same if it occurs in the first trimester or in the third one. In the first case, a possible abortion is the first diagnosis to make, with findings of irregular borders of the gestational sac, or to see the fetal pole without heart movement, or an echolucent image in the cervical canal. In such a case, the woman must be sent to a secondary level of health care, in order to remove the dead embryo and clean the uterine cavity. In the second and third trimesters, the physician must pay attention to the position of the placenta, and to any echolucent image between the placenta and the uterine wall; these findings may facilitate the diagnosis of either a low position of the placenta or of a retroplacentarium hematoma, with the consequent treatment at the secondary or tertiary healthcare levels. Also when the physician identifies abnormal amounts of amniotic fluid, it is important to always check if the stomach is present in the site of the abdominal fetal cavity, if the fetal urinary bladder is full, and also to identify the fetal kidneys. Never forget in the same situation to ask the patient for previous history of diabetes, and to measure the placenta, and assess if there is a single fetus. Ideally, pregnancy management should be done by an obstetrician. In rural areas such specialist may not be present and then the doctor (or midwife or nurse practitioner if a doctor is not available) will have to identify if the woman is pregnant or not and take the elementary measures, such as making the first ultrasound explorations, if the woman exhibits any acute symptoms that may be suspicious of complications, as explained previously. For a pregnancy with a normal evolution, the clinician in the rural health center should be able to evaluate fetal images and implement basic measures prior to the baby's delivery.

2.6.3 Ectopic Pregnancy

The ultrasonography appearances of ectopic pregnancy may vary greatly, particularly if other changes occur in the adnexa. In addition to a positive pregnancy test, one commonly finds an enlarged uterus without an embryonic cavity and adnexa

changes. The diagnosis can be established only if the ectopic fertilized ovum is found with an intact embryo. Transvaginal ultrasonography is the diagnostic choice.

However, it is important to note that ultrasound not always allows to make the diagnosis of ectopic pregnancy. First, it is important to ask the patient when she had her last menstrual period, and if the physician has any doubt, a laboratory test for pregnancy should be carried out. If the test is positive and consistent with clinical findings, even though there are no positive ultrasonographic findings, the patient must be sent to the secondary level of health care.

Another situation is a woman with clinical findings of ectopic pregnancy and with ultrasonographic images showing an enlargement of the ovaries or any complex mass in any uterine adnexa, with or without an embryonic gestational sac, and with or without free fluid in the peritoneal cavity. In such a case, the patient needs to be sent urgently to another level of attention for surgical management.

2.7 Gynecological Problems not Related to Pregnancy

Common gynecologic symptoms in the medical room are presented by women who have missed their period or who have gynecological bleeding. In these cases, the ovaries could be evaluated first with ultrasound.

2.7.1 Normal Uterus Size

The fluid-filled bladder can be used as the acoustic window for transabdominal ultrasonography of the uterus (and of all organs of the minor pelvis). However, transvaginal ultrasonography provides much more precise information [24]. Table 2.6 provides information of the size of the uterus versus age.

The uterus may be larger in multiparae and in women with poor involution after birth, and it is smaller again in older women. Ultrasound is able to provide a good topographic assessment (position, anatomical abnormalities such as double uterus) and can detect changes in the uterine cavity (particularly in the endometrium) during the course of the menstrual cycle (see Fig. 2.22). Additional echography is also useful for detecting uterine tumors and cystic lesions [24].

Table 2.6 Size of the uterus

Prior to puberty	2–3.3 × 1 cm
Childbearing age	5–8 × 1.6–3 cm

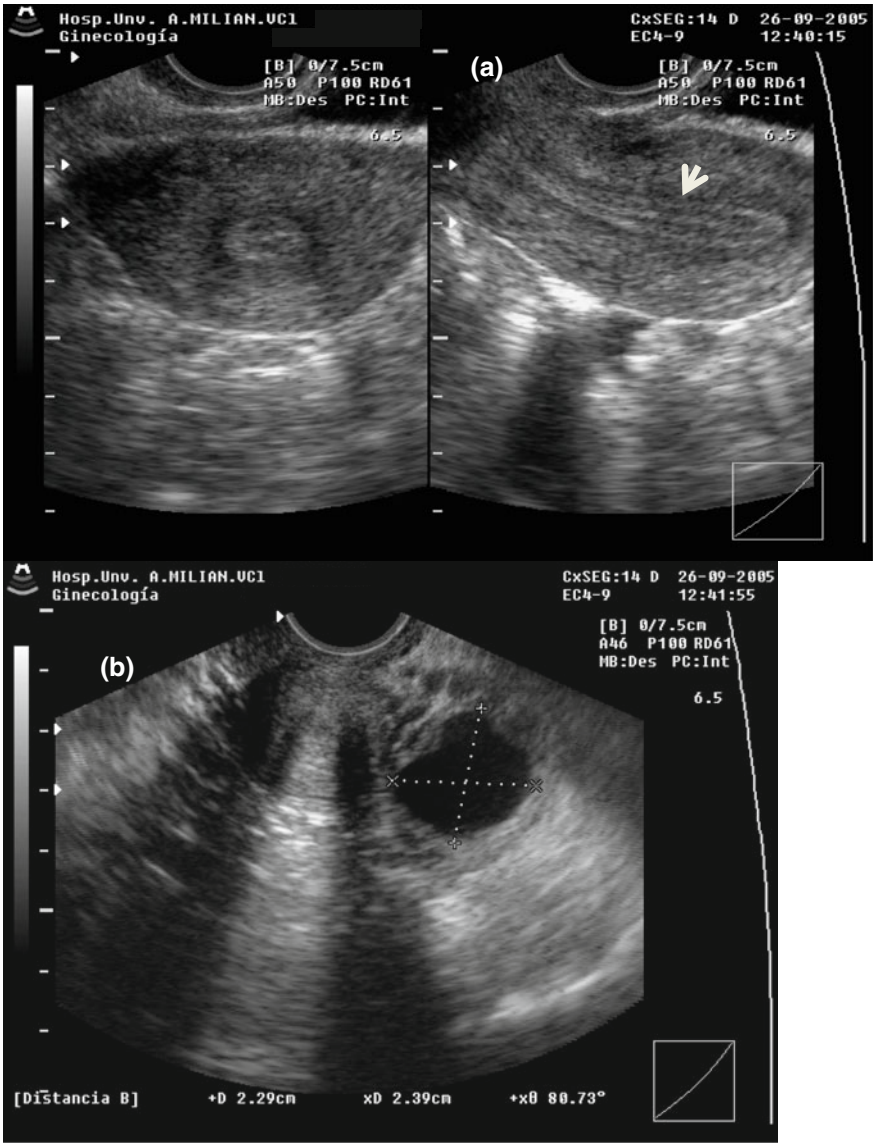

Fig. 2.22 Normal trilaminar endometrium **a** with mature follicle in the left ovary (*white arrow*), **b** on the 14th day of the cycle

2.7.2 Uterine Myomatosis

Diffuse hyperplasia of the myometrium is normal in multiparae. In these women, the myometrium appears less reflective than the endometrium. This finding is considered pathological only when it coexists with menorrhagia. Circumscribed

myomas are usually found in sub-serous positions. They have a polycyclic appearance and are smoothly demarcated from their surroundings. Degenerative changes may occur in myomas due to excessive growth or poor circulation, which gives them an irregularly spotted, hypoechoic appearance with plaque like foci of calcifications in some cases.

2.7.3 *Ovarian Cysts and Tumors*

Simple cystic ovarian masses are a common finding; they usually correspond to corpus luteum cysts or retention cysts, and their appearance changes throughout the course of the menstrual cycle. Ovarian cysts are spherical unilocular masses with smooth walls, anechoic contents and dorsal acoustic enhancement [24]. Tumors may produce different images (see Fig. 2.23).

A particular tumor that requires special attention is the ovarian cystadenoma. This tumor may become quite large and contain septa, but the two types cannot be reliably distinguished by ultrasonography. The contents of ovarian cyst adenomas are usually echolucent, but the contents of mucinous ovarian cystomas are weakly echogenic. Mucinous types may be difficult to distinguish from endometriosis cysts or degenerated, pedunculate (subserous) myomas that occur in uterine myomatosis [24].

Table 2.7 lists the echographic appearance of adnexal tumors.

Fig. 2.23 Giant cyst of the right ovary, with thick septum and nodular wall, signs of a malignant cyst

Table 2.7 Ovarian tumors

Tumor	Cystic unilocular	Cystic multilocular	Solid cystic	Solid
Corpus luteum	+			
Cysts with hemorrhage		+	+	
Desmoids	+	+	+	+
Endometriosis	+	+	+	+
Ectopic pregnancy		+	+	
Ovarian fibroma				+
Ovarian cystoadenoma		+		

Echographic appearance of adnexal tumors

All the gynecological uterus and adnexal masses need to be evaluated by a gynecologist at the second level of health care to make the correct diagnosis, sometimes under laparoscopic view and biopsy. But at least, the ultrasound exam in rural areas is a tool to identify if the symptoms come from the gynecological structures and can rule out uterine and adnexal lesions, which the physician can see during the exploration.

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