The perinatal autopsy

The value of the perinatal autopsy

The perinatal autopsy can provide important information to the family, the clinician, and society [1–3]. When the parents give their consent for a post mortem examination on their baby, they are hoping to know why and how their baby died. It is quite reassuring to the parents to know that whatever has gone wrong, it did not happen because they did something wrong, and that there was nothing they could have done to prevent it. In cases where the pregnancy was terminated due to malformations, the post mortem can confirm, modify, or exclude a prenatal diagnosis, i.e., it serves as an audit tool for both diagnosis and diagnostic techniques. In all cases, whether it was a miscarriage, a stillbirth or a termination of pregnancy due to fetal malformations, the information obtained from the autopsy can help both the parents and the clinicians to plan for future pregnancies, and help the clinicians to counsel the parents about possible recurrence risks.

In cases of neonatal deaths, the perinatal autopsy can provide the neonatologists with information about the accuracy of their diagnoses and any conditions that were not recognized. It can also provide information about the effects of various treatments and drugs on the tissues and organs.

The autopsy is an important teaching tool for a variety of health professionals involved in the care of women and their babies. This includes pathologists, pediatricians, neonatologists, obstetricians, midwives, nurses, and bereavement officers.

The perinatal autopsy provides information that can be used to promote public health. Accurate information on causes of death is essential for national perinatal mortality data and health service planning.

Autopsy protocol

Clinical information

Adequate clinical information is essential for any post mortem examination [1–4]. This is because having the appropriate information helps the pathologist to decide the best approach to perform the examination, e.g., method of evisceration and removal of the brain, and what ancillary investigations are necessary. In addition, knowing what investigations have been carried out during pregnancy or after delivery would help prevent unnecessary duplication.

Having the mother’s (and baby’s) clinical notes would be the ideal situation. However, this may not be possible since, quite often, babies are sent to different hospitals for post mortem examination. The alternative is an appropriately completed autopsy request form. Such a form should contain information about the mother’s past medical history, including any conditions that may affect pregnancy outcome, e.g., chronic hypertension and diabetes. History of previous pregnancies and their outcome is essential. For the index pregnancy, the gestation based on the mother’s last menstrual period, as well as any revisions using ultrasound scans, should be stated. Any pregnancy complications such as pre-eclampsia, gestational diabetes, pyrexia, and antepartum hemorrhage should be included. Investigations undertaken during pregnancy and their results are essential. If the mother’s clinical notes are not available, a copy of any abnormal scan reports is essential, especially if the pregnancy had been terminated due to fetal anomalies. The form should include time and date of delivery, mode of delivery, and birth weight. For live births, the condition of the baby at birth, postnatal progress, including any medical procedures, and clinical cause of death should be included.
Equipment

The perinatal post mortem requires a fully equipped mortuary with abundant light and suitably sized tables and benches. Advanced photography equipment (cameras and stands) that allow photographing small fetuses and organs are invaluable for a perinatal pathologist. If this is not available, a modern small camera with a good macro function should suffice. Radiographic equipment, usually in the form of a Faxitron, is also essential (see Chapter 18). Autopsy examination of fetuses and neonates requires accurate weighing scales. An electronic balance with a digital display is ideal to record weights to the nearest 0.1 g. Measuring the body and foot lengths can be performed using a metric ruler with calipers, or a fixed board with a fixed end and movable foot. A string or tape can be used for circumferential measurements.

Dissection of small babies and fetuses requires blades, scissors, forceps, and probes of various sizes (Figure 1.1). Appropriately sized bowls and brushes are useful to handle small and soft brains. A mounted magnifying glass or a dissecting microscope may be needed for the examination of small fetuses and organs.

Procedure

Weights and measurements

The body weight and external measurements should be accurately recorded and compared with appropriate gestation-related normal values (see Chapter 20). Standard measurements include crown–rump, crown–heel, head circumference, and foot length. These should be recorded to the nearest 0.5 cm. The foot length is considered the most reliable to assess gestation in cases where the fetus is macerated. Other optional measurements include chest and abdominal circumferences (at the level of the nipples and umbilicus, respectively). The chest circumference may be of value in cases of skeletal dysplasia.

All major organs (thymus, heart, lungs, liver, spleen, pancreas, adrenals, kidneys, and brain), as well as the placenta, should be weighed and compared with expected values for gestation.

Radiology

A Faxitron whole-body radiograph is a useful investigation in the perinatal autopsy. Antero-posterior and lateral views are the basic requirements. Further images of individual sites, e.g., limbs or chest, can be obtained as required.

A high-quality radiograph is essential for the investigation of skeletal dysplasia. It can also be used to assess gestational age and detect soft tissue calcification.

In some centers, post mortem MRI is increasingly used as an adjunct to the post mortem examination, especially in cases of termination of pregnancy due to brain malformations. MRI is very useful in imaging the soft brain before the skull is opened, especially in macerated fetuses [5,6]. For further information please refer to Chapter 18.

Photography

The minimum requirements are anterior, posterior, and lateral images. Further images of dysmorphic features and any other abnormalities detected on external and internal examinations are obtained as required. A photographic record of any abnormality is more reproducible and more accurate than any written description. Clear photographs are not only useful for the pathologist, but also for clinical geneticists, and if a second opinion is required on difficult cases. They can also be used to demonstrate the various abnormalities in perinatal mortality meetings and for training and teaching purposes. Some centers provide photographs for families if requested.

External examination

Similar to the neonatal check carried out on newborn babies before they are discharged from hospital, the external examination is a “tip to toe” check looking for any abnormalities in the baby or fetus. Assessing skin color and the presence or absence of skin slippage, and...
its extent if present, allows the pathologist to assess the degree of maceration and gives clues about the time of death [7] (Table 1.1). It has to be said, however, that this may not be reliable in very small fetuses.

Skin color also helps in assessing/confirming gestation of the baby, as very pre-term babies have bright pink skin while post-term babies can have dry, wrinkled skin. Pale skin can indicate fetal anemia, and in near-term or term babies it raises the possibility of feto-maternal hemorrhage; the pathologist can alert the clinician or the laboratory to carry out a Kleihauer test (if not already done) while the opportunity is still there. Other features that can be assessed include bruising, petechial hemorrhages, edema, and jaundice in neonatal deaths.

Together with the given gestation on the post mortem request form, body weight, and external measurements, the fetal growth can be assessed to determine if the fetus is appropriately grown for gestation or if the fetus is small or large for gestation. Small for gestational age or growth-restricted babies can look “tall and thin” with a large head and have thin thighs compared to what might be expected in appropriately grown babies. This would be more obvious in near-term or term babies. Growth-restricted babies may also have dry skin, even if they are pre-term.

The fetus is then examined, looking for dysmorphic features. These can give clues to a specific diagnosis, e.g., Down’s syndrome, and to possible internal malformations, thus allowing the pathologist to decide the approach to be taken for the rest of the examination. The pathologist can also decide what ancillary investigations may need to be carried out, e.g., cytogenetics. Other abnormalities that can be seen include abnormalities of posture, such as positional talipes, arthrogryposis, amputated limbs, neural tube defects, and abdominal wall defects.

The attached umbilical cord can also provide useful information, especially if the placenta is not submitted for examination. The umbilical cord should be measured (length and diameter) and the number of vessels recorded. Abnormalities such as hypercoiling and strictures at the fetal end (Figure 1.2) should be assessed as these might give important clues in miscarriages and stillbirths.

Any injuries related to delivery, such as abdominal wall defects, should be carefully recorded, even in miscarriages and stillbirths, and these should be differentiated from true malformations. It is not uncommon that parents want to see photographs of their babies and it is critically important that any potential complaints against the mortuary staff or the pathologist. In addition, cases of possible birth trauma in intrapartum or neonatal deaths are likely to be investigated by the coroner or medical examiner. Therefore, careful and accurate documentation of any injuries cannot be overemphasized.

In cases of neonatal death, sites of venepuncture, drains, catheters, and surgical incisions should be noted. All drainage tubes, central lines, and umbilical arterial and venous catheters should be left in situ until the position of the tip is checked internally.

### Internal examination

#### Initial incisions

The incision used to open the body can be done in many ways. This depends on the size of the fetus or

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**Table 1.1** External features of maceration and approximate timing of fetal death

<table>
<thead>
<tr>
<th>Timing</th>
<th>Gross skin findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 6 hours</td>
<td>Skin desquamation ≥1 cm</td>
</tr>
<tr>
<td>≥ 12 hours</td>
<td>Skin desquamation of face, back, or abdomen</td>
</tr>
<tr>
<td>≥ 18 hours</td>
<td>Skin desquamation ≥5% of body surface</td>
</tr>
<tr>
<td>≥ 18 hours</td>
<td>Skin desquamation involving two or more body regions</td>
</tr>
<tr>
<td>≥ 24 hours</td>
<td>Skin color brown or tan</td>
</tr>
<tr>
<td>≥ 2 weeks</td>
<td>Mummification</td>
</tr>
</tbody>
</table>

Source: Data from D. Genest and D. B. Singer [7].

**Figure 1.2** Hypercoiled umbilical cord with stricture at the fetal end.
baby, potential malformations predicted from the clinical information provided and/or external examination, and, to a lesser extent, personal preferences. A single straight midline incision from the sternal notch to the symphysis pubis is usually adequate for small fetuses. A T-, Y-, or inverted Y-shaped incision can be used for bigger babies. In a T incision, an incision is made from one shoulder tip to the other. A vertical incision is then made from the sternal notch down to the symphysis pubis (Figure 1.3). A Y-incision would be preferable if the neck is going to be dissected. Each limb of the Y represents an incision that runs from just behind the ear along the sternocleidomastoid muscle to the sternal notch. A vertical incision is then made from there to the symphysis pubis. An inverted Y-incision is useful for good exposure of the bladder and umbilical arteries. A vertical incision is made from the sternal notch to just above the umbilicus. The limbs of the Y represent two incisions from just above the umbilicus to the groin. One limb of the Y can be continued to the thigh or knee if a limb muscle is going to be sampled or the femur needs to be removed. If the body is likely to be viewed after the autopsy, a T-shaped incision would be preferable.

The thorax

On dissecting the skin and subcutaneous fat from the rib cage, the amount of subcutaneous fat can be assessed. This will give additional information regarding the fetal state of nutrition. An average-term baby should have a subcutaneous fat thickness of approximately 5 mm. A growth-restricted baby might have subcutaneous fat thickness as little as 2 mm, while a macrosomic baby might have subcutaneous fat thickness as high as 10 mm. The volume of muscle on the chest can also be noted as poor muscle volume raises the possibility of myopathic or neuropathic disorders. This should prompt careful examination of the nervous system, sampling of limb muscles, and taking muscle samples for freezing and electron microscopy.

The shape of the thoracic cage can then be inspected. A narrow bell-shaped chest can be a feature of skeletal dysplasia and may suggest the possibility of pulmonary hypoplasia. In neonatal deaths the possibility of pneumothorax should be excluded. This can be done by immersing the body in water and inserting a cannula into each pleural cavity through the sixth intercostal space in the mid-axillary line. If a pneumothorax is present, gas bubbles will emerge from the cannula when the trocar part is removed.

The thoracic cavity can be accessed by cutting through the sternoclavicular joints and rib cartilages, approximately 5 mm medial to the costochondral junction on each side, and removing the sternum. The thoracic contents should be examined in situ to confirm position and appearance of the organs and their relationships. The presence of any space-occupying abnormality, e.g., effusion, abdominal organs through a diaphragmatic hernia or tumor, should be recorded. Samples from the lung or effusion, if present, can be taken for microbiology at this stage. The position of the tips of any chest drains should be located and any lung or heart damage excluded.

The thymus is a large bilobed organ overlying the superior aspect of the heart and the roots of the great vessels. It can extend into the neck for a variable distance. The thymus shrinks with longstanding stress of any cause. Therefore, growth-restricted fetuses or neonates who have been in the intensive care units can have a very small thymus. This should not be confused
with cases of Di George syndrome, where the thymus is usually absent. The thymus should be carefully dissected off the pericardium without damaging the imme-

nate vein, which runs behind it. Petechial hemorrhages secondary to hypoxia may be present.

The pericardium is opened, noting the presence of any effusion or blood. It can then be completely removed by dissecting it off the roots of the great vessels and sides of the atria, taking care not to damage the pulmonary veins at the back. This will expose the heart and great vessels; the exterior of the heart and its connections can be examined in situ. The presence or absence of epicardial petechiae should be noted. The position, shape, and size of the heart can be checked. The presence and position of the superior and inferior vena cavae should be confirmed. If the innominate vein behind (and sometimes in front of) the thymus is not identified, the presence of a persistent left superior vena cava should be ascertained. The pulmonary veins should be inspected to confirm their drainage into the left atrium. The atria and their appendages can be checked to determine atrial situs. In fetuses and early neonatal deaths, the right and left ventricle should be more-or-less equal in size. The ascending aorta and pulmonary artery should also be equal in diameter, with the pulmonary artery crossing in front of the aorta. The aortic arch and its branches and the ductus arteriosus are then checked. If all of the above are normal, then a significant cardiac malformation is unlikely to be present (see also Chapter 9).

Dissection of the heart can be carried out in situ, or after removing it en-bloc with other organs. Some pathologists prefer to examine the heart in situ if all of the above external inspection is normal. This is because the heart would still be in its natural position and with natural connections, and therefore more stable and easier to examine. If there is any suspicion of congenital heart disease, the heart should be photographed, removed en-bloc, and examined after fixation. This can be done after as little as 2–3 hours if the body has to be released back to the family as a matter of urgency. Otherwise, the examination can be left until the following day. Some pathologists, on the other hand, prefer to examine the heart in the fresh state [2].

**Evisceration**

Evisceration can be carried out in several ways. The most important aspect is that organs should not be removed individually. The organs can be removed in one (Rokitanski), two, three, or four blocks, depending on the potential abnormalities that might be identified and personal preferences. The author prefers the method adopted by Wigglesworth [1,2], which includes removal of the viscera in four blocks: neck structures (with or without the tongue) and thoracic organs; small and large intestines; upper abdominal organs; and the urogenital organs. If there is a possibility of anomalous venous drainage, the neck and thoracic organs should be removed in continuity with the upper abdominal organs.

**Neck and thoracic organs**

After removing the sternum, the neck structures can be dissected as far as the top of the larynx. These can then be brought down together with the thoracic organs by gentle traction and separation from the prevertebral fascia. The esophagus and blood vessels are then cut at the level of the diaphragm in order to free this organ block. Some pathologists prefer to remove all the neck structures, including the tongue. Others, including the author, do not advocate removing the tongue in the routine perinatal post mortem unless there is a specific indication, such as possible upper airway obstruction or malformation. Leaving the tongue in situ allows better cosmetic result after reconstruction, especially if the family wants to view the body after the post mortem examination.

This organ block is dissected from the back by opening the posterior wall of the esophagus. This allows the identification of possible esophageal atresia and tracheo-esophageal fistula. The esophagus can then be dissected away from the posterior wall of the trachea. The larynx and trachea are then opened down their posterior wall as far as the two main bronchi. The lungs are examined, checking size, lobation, and the presence of pleural petechiae. In the perinatal autopsy it is rarely possible to identify specific pathology in the lungs macroscopically since the lungs nearly always appear airless and congested. The diaphragm is then examined and checked for completeness.

**Examination of the heart**

Whether the heart is examined fresh or fixed, it should be opened following the flow of blood through the heart and assessing the morphology of the chambers and arterial trunks (sequential segmental analysis) [8,9]. There are circumstances, however, in which the heart may be opened differently. For detailed examination of the abnormal heart, see Chapter 9.
The heart is placed in the anatomical position while it is still attached to the lungs. The right atrium is opened by cutting between the opening of the superior and inferior vena cavae along the right border of the heart. The oval fossa and opening of the coronary sinus can then be identified. The foramen ovale should be largely covered by a membrane, but it should be still probe patent. In small fetuses the membrane covering the foramen ovale is very thin and may appear absent on first impressions. Any septal defects should be noted and their size and location documented. The tricuspid valve can be inspected, looking for atresia, stenosis, or dilatation. The right ventricle can then be opened by cutting down the right lateral border of the heart to the apex along the posterior coronary artery, and then upwards along the outflow tract through the pulmonary valve and into the pulmonary artery. The cut can be continued through the ductus arteriosus, thus confirming its presence and patency at this stage, or it can be done after examining the pulmonary valve and arteries. The tricuspid valve is examined, looking for abnormalities of cusp number and morphology. The trabecular morphology of the right ventricle is then confirmed and any defects in the ventricular septum can be assessed. The pulmonary valve is examined looking at the number and morphology of the cusps and any pulmonary outflow obstruction. The main pulmonary trunk and the right and left pulmonary arteries are inspected, and the presence and patency of the ductus arteriosus assessed, if not already done.

The next step is to open the left atrium between the pulmonary veins. The mitral valve can be inspected looking for atresia, stenosis, or dilatation. The left ventricle can then be opened by cutting down the left lateral border of the heart to the apex, and then upwards along the outflow tract, following the interventricular septum using the left anterior descending coronary artery as a guide. To open the aorta, the prossector will have to cut through the aortic valve and pulmonary trunk. Therefore, the aortic valve needs to be inspected for possible atresia or stenosis before this is done. The mitral valve is examined looking for abnormalities of cusp number and morphology. The trabecular pattern of the left ventricle is noted. The interventricular septum is inspected again from the left side since it is easier to identify small septal defects, which may have been obscured by the coarse trabeculations of the right ventricle. The aortic valve is then examined, looking at the number and morphology of the cusps and any outflow obstruction.

In larger fetuses and neonatal deaths the coronary artery ostia should be identified and their origin ascertained. The aortic arch and its branches are then inspected, looking for possible coarctation, especially in the pre-ductal area.

**The abdominal cavity**

It is useful to start by inspecting the peritoneal cavity and its contents before any dissection, especially in the macerated fetus. The presence of ascites or hemorrhage can be checked. The appendix and Cecum should be located in the right side of the abdomen to exclude intestinal malrotation. The gonads can be located at this stage, before removing the intestines, to confirm the sex of the baby, especially in the very small fetuses where the external genitalia may be difficult to assess. The presence and position of the umbilical arteries, umbilical vein, liver, stomach, spleen, and pancreas can be assessed. The intestines can then be removed by cutting through the fourth part of the duodenum as it emerges from the retroperitoneum behind the transverse colon and just below the stomach. The intestines are gently pulled and the mesentery divided all the way down to the rectum. This procedure allows any abnormalities such as atresias, duplications, infarctions, or enterocloctis to be identified. The upper abdominal organs can then be removed in one block by cutting the diaphragm along its peripheral insertions and gently separating the liver, pancreas, and spleen from the fascia covering the adrenal glands and aorta. The various organs can then be separated and examined. The abdominal parts of the inferior vena cava and aorta are opened *in situ*. If the baby had umbilical vein and/or artery catheters inserted, the position of the tips and any thrombus should be noted. The position and patency of the renal arteries can then be checked.

The adrenals and urinary tract are then inspected. If there is no evidence of obstruction, i.e., enlarged bladder, dilated tortuous ureters, or hydronephrotic kidneys, the adrenals and kidneys can be removed individually. Otherwise, the whole urinary tract should be removed in continuity. In neonatal deaths the adrenals and kidneys can be checked for hemorrhage or infarction.

The internal genitalia are inspected. The uterus can be checked for malformations such as bicornuate uterus. The appearance of the fallopian tubes and ovaries is noted. In most fetuses the testes will be in the abdomen, but in larger babies or neonates they may be in

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**Chapter 1: Perinatal autopsy, techniques, and classifications**

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the inguinal canal or scrotum. A sample from the psoas muscle can be taken for histology and freezing.

If using the Rokitanski method, all the organs are removed in one block after removing the intestines, and the dissection proceeds in a similar way as that described above, separating the organs into three blocks: thoracic, abdominal, and genitourinary.

The head

The scalp is inspected externally, looking for edema, caput, and bruising. The presence of localized swelling/mass may suggest an underlying encephalocele. The head may be visibly enlarged in cases of severe hydrocephalus that have not been terminated early in pregnancy. In intrapartum and neonatal deaths, any bruising, hematomas, and ventouse or forceps marks should be carefully documented.

The scalp flaps are then reflected forwards and backwards and the inner aspect is examined for the presence of edema and hemorrhage. After instrumental deliveries, subgaleal or subaponeurotic hemorrhage may be present. The size of the anterior fontanelle and width of the sutures is then noted. The appearance and shape of the skull bones and the presence of any defects are documented, including position, size, and any protruding tissues. If there are any fractures, their position, extent, and appearance should be noted. In some skeletal dysplasias, the skull bones may be very thin and even soft. Severe craniotabes in rickets may present with a completely fibrous and pliable calvarium.

The posterior flap of the scalp is reflected to expose the occipital bone and cervical vertebrae. After removing the soft tissues and muscle, the posterior aspect of the atlas will become visible. This can be carefully removed by cutting the bone on either side, thus exposing the upper spinal canal (Figure 1.5). A small sterile needle can then be carefully inserted into the canal to obtain a sample of the cerebrospinal fluid (CSF), if required. Alternatively, the dura can be incised and the CSF obtained using a sterile pipette. The cervical vertebral laminae can then be removed as far down as desired to obtain an adequate length of cervical spinal cord (approximately 5 cm is adequate for routine examination). The cord can then be divided and separated from the nerve roots and dura. The incision in the dural covering of the cord can be extended upwards till the foramen magnum. This would expose any downward displacement of the cerebellum in cases of spina bifida and brain swelling.

The cranial cavity is then opened by making parallel incisions in the anterior fontanelle away from the midline. This is to ensure that the sagittal sinus is not damaged. The incisions are then extended forwards and backwards on either side of the midline. The frontoparietal and parieto-occipital sutures are then cut on each side. Care should be taken in all these steps that the scissor point is kept up against the bone to avoid damaging the brain. The frontal and parietal bones can then be opened in order to expose the brain. The cerebral gyral pattern is inspected and compared with what is expected for gestation. The normal gyral pattern is maintained in macerated stillbirths and growth-restricted babies and can be used to estimate gestation and the time of death. The gyri may

Figure 1.4 A "question mark" scalp incision.
be flattened in cases of severe hydrocephalus, and in case of edema in neonates. The gyral pattern may be abnormal in certain malformations. The presence, site, and size of any subdural or subarachnoid hemorrhage should be documented.

The brain is then taken out underwater (or saline, if available). This technique is useful in all perinatal post mortems, especially small and macerated fetuses, because the water will support the brain and free the prossector’s hands to separate the brain from the dura. Depending on the size of the fetus, the entire body can be submerged under water if the fetus is small, or only the head can be tipped backwards so that the weight of the brain is supported by the water as it falls backwards from the cranial cavity. After opening the skull bones, the sagittal sinus is divided anteriorly and lifted backwards. The head of the fetus is tilted backwards until the frontal lobes begin to fall away from the frontal bones. The brain can be gently teased backwards using the scalpel blade or a brush until the olfactory bulbs

Figure 1.5 Sampling the cerebrospinal fluid (CSF). (a) After reflecting the skin, the skeletal muscle at the back of the neck is removed to expose the atlas (asterisk). The bone is cut using a suitably sized bone cutter. (b) The top of the spinal canal is exposed after removing the posterior aspect of the atlas. (c) The CSF is sampled using a sterile needle.
and optic chiasma appear. These can be divided, allowing the brain to fall further backwards. This will gradually expose the front of the brainstem and the cranial nerves can be divided from the pons and medulla. When the tentorium appears it can be separated from the occipital bone by cutting it as close to the bone as possible. This will allow the cerebellum to fall backwards. With further tilting of the head backwards, the entire brain will fall onto the occipital bone and into the water.

The dura can be inspected for any hemorrhage and tears, especially in the posterior falx and tentorium, which can be damaged during delivery.

Very macerated brains can be removed with the dural coverings intact in order to preserve as much as possible of the brain. The brain, with its coverings, is then fixed prior to examination. If the brain is fixed within the dura, the weight of the dura should be subtracted from the total weight before comparing with appropriate tables.

In cases of suspected hydrocephalus or posterior fossa abnormalities such as Dandy–Walker malformation, the brain should be removed using the posterior fossa approach (Figure 1.6). After reflecting the scalp, the occipital bone is carefully removed by cutting the sutures around it. The bone is then carefully lifted and separated from the underlying dura. This is to ensure that the cerebellum and potential underlying structures such as a Dandy–Walker cyst are preserved. The laminae of the upper cervical vertebrae can then be cut on either side to expose the upper cervical spine. The presence of an Arnold–Chiari malformation would be confirmed after this step. The contents of the posterior fossa and upper cervical spine are inspected and photographed before removal of the brain is attempted. This is particularly important when the fetus is macerated and if a cyst is present, as it is quite likely that any abnormality would be lost as the brain is removed. The cervical spinal cord is then divided and brain can be taken out using the method described above.

The fetal and neonatal brains should be fixed prior to examination, unless the family explicitly states that they want the brain to be returned to the body immediately after the post mortem examination. Babies’ brains are soft due to higher water content and incomplete myelination. If they are cut in the fresh state, they will simply collapse and much useful information will be lost. For example, it would be extremely difficult to diagnose or differentiate between severe hydrocephalus and holoprosencephaly (Figure 1.7). In addition, the presence and extent of any intraventricular hemorrhage would be impossible to ascertain. A fresh brain would have to be cut in thick slices and focal abnormalities may be missed. A rough guide for the minimum length of fixation is 2–3 days for fetuses of around 20 weeks gestation and 5–6 days for term babies and neonates. The brain can be fixed in 10% or 20% formaldehyde following department protocols.
After fixation the brain is inspected further and any abnormalities noted on the initial inspection can be confirmed. The cerebellum and brainstem can then be detached by an incision across the junction of the upper pons and midbrain. This allows the presence and patency of the aqueduct to be confirmed. The forebrain and hindbrain can then be weighed if required. The cerebellum is separated from the pons and medulla and the presence and completion of the vermis is confirmed. The cerebellar hemispheres are then divided to reveal the dentate nucleus. The pons and medulla are serially sliced and sampled. The cerebrum is sliced coronally from the basal aspect, starting at the level of the mammillary bodies. Each slice should be no more than 1 cm thick.

The spinal cord
The spinal cord in fetuses and neonates can be removed by an anterior or a posterior approach. The anterior approach is convenient as it does not involve making extra incisions in the body and the vertebral column is easily accessible after evisceration. An intervertebral disc in the lower lumbar region is divided in the coronal plane. The vertebral pedicles on each side are then divided using a small bone cutter until the vertebral bodies can be lifted to expose the spinal cord. The pedicles are divided on each side in turn up to the top of the cervical spine. It is useful for subsequent reconstruction to leave the vertebral bodies attached to the top of the spine. The filum terminale is then divided and elevated with forceps and the spinal nerve roots divided on either side, taking care not to cut the dura. This protects the spinal cord and makes handling easier. As the brain has already been removed, the spinal cord will be freed once all the spinal nerve roots have been cut.

In cases of spina bifida and Chiari malformation, the spinal cord can be removed in continuity with the brain using the posterior approach. The skull is opened using the posterior fossa approach as above. The skin incision already made on the back of the neck is extended down the entire spine. The vertebral laminae are then cut on either side to expose the spinal cord. This can be freed and the brain removed as above, with the cord attached (Figure 1.8).

Bones
In routine perinatal post mortem examinations, the anterior aspect of the fifth or sixth rib, including the adjacent costochondral junction, should be taken for histological examination. This allows the assessment