Epidural anesthesia was first reported by Sicard and Cathelin in France, in 1901. Whereas continuous techniques were pioneered by Hingson et al. and Tuohy, Dawkins and Bromage established lumbar epidural anesthesia as the gold standard for the management of labor pain. As these techniques evolved, undesirable effects became apparent; those that were repeatedly seen were judged to be side effects of the technique, and were accepted as an expected and predictable part of practice. Less common, more serious outcomes may be considered complications; these events may result in significant morbidity or mortality if left unchecked. Anesthesiologists should take great care to identify those patients at risk of developing serious complications, and must make risk–benefit evaluations in determining the suitability of a particular technique. In some cases in which the absolute risk may be difficult to quantify, and the outcome may be potentially catastrophic, the practitioner may exclude an entire subset of the patient population (e.g., the anticoagulated patient and the risk of epidural hematoma). There are a multitude of factors that can lead to adverse epidural usage outcomes. Safety in clinical practice is a complex system, which is beyond description within the confines of this paragraph. However, careful patient selection and adherence to established guidelines form the cornerstones of complication prevention.

Recent research has focused on the usage of ultrasound and epidural stimulation techniques to aid accurate placement of the epidural catheter. Although some may consider these new techniques cumbersome or unnecessary, they are valuable teaching tools, and are promising developments that have the potential to improve the success and safety of epidural anesthesia. Time will tell which of these techniques will become widely accepted and, more importantly, will reduce the incidence of epidural complications. This chapter reviews these new relevant developments and focuses on the clinical aspects of epidural complications in terms of their incidence, prevention, and management.

New Developments in Epidural Placement

Ultrasound

Ultrasound allows the real-time visualization of anatomic structures and offers the potential to guide epidural needle and catheter placement. Ultrasound is useful for guiding peripheral nerve block placement in adult patients; however, its application...
in central neuraxial blockade in adults and children remains limited, and its use is not as yet widespread.

Real-time ultrasound imaging of the lumbar spine is a simple procedure, and there is some evidence that it can aid the placement of lumbar epidural catheters and the performance of combined spinal-epidural anesthesia. Ultrasound use improves the learning curve of obstetric lumbar epidural catheter placement for anesthesia trainees. In patients with anticipated difficult epidural localization, it is helpful in estimating lumbar epidural depth, and facilitates ease of placement. Although ultrasound imaging has been used to guide lumbar needle placement, it may be of limited value in the thoracic region, particularly in older children and adults when visualization of the spinal cord and relevant structures is sought. Calcification of the posterior vertebral bodies in children older than 6 months prevents reliable imaging of the spinal cord. At the present time, ultrasound guidance is helpful in the lumbar region for most patients, whereas its use for thoracic epidural placement is of value only in infants and small children because their vertebrae are not fully ossified.

**Epidural Stimulation Test**

Whereas peripheral nerve and spinal cord stimulation techniques have been in use for many years, it is only recently that electrical epidural stimulation has been used to confirm and guide catheter placement in the epidural space. The epidural stimulation test confirms epidural catheter placement through stimulation of the spinal nerve roots (not the spinal cord) with a low-amplitude electrical current conducted through normal saline via an electrically conducting catheter. The stimulating catheter setup requires the cathode lead of the nerve stimulator to be connected to the epidural catheter via an electrode adapter, while the anode lead is connected to an electrode on the patient's skin as a grounding site. To avoid misinterpretation of the stimulation response (e.g., local muscle contraction thought to be epidural stimulation), the ground electrode should be placed on the lower extremity for thoracic epidurals and on the upper extremity for lumbar epidurals. Correct placement of the epidural catheter tip (1–2 cm from the nerve roots) is indicated by a motor response elicited with a current between 1–10 mA. Any motor response observed with a significantly lower threshold current (<1 mA) may suggest that the catheter is in the subarachnoid or subdural space, or is in close proximity to a nerve root. In these rare cases, a motor response is elicited with a significantly lower threshold current because the stimulating catheter may be very close (<1 cm) to the nerve roots or because it may be in direct contact with highly conductive cerebrospinal fluid (CSF).

**Safety of Electrical Stimulation**

Electrical stimulation has been applied to neural structures for neurophysiologic evaluation and pain control for many years, and has proven to be safe. The safety of the epidural stimulation test is not completely known, but it is anticipated that the risk of a brief intermittent electrical stimulation used in this setting would be lower than the risk of chronic epidural stimulation used in long-term pain management. In addition, epidural stimulation uses milliamperages within the range used for patients with chronic pain disorders (4–30 mA) and for intraoperative monitoring during spinal surgery (2–40 mA). Although no known complications or patient discomfort have resulted from the epidural stimulation test, it has been recommended to keep the current below 15 mA and the stimulation time as brief (<minutes) as possible. In particular, the current output must be carefully increased from zero and stopped once motor activity is visible to ensure that all motor responses, even those elicited with low current (<1 mA), are detected. The nerve stimulator must be sensitive to allow a gradual increase in current output to at least 10 mA.