should be noted that serum bromide levels may rise, though the patient appears to be improving clinically. The reason for this is poorly understood but probably involves liberation of bromide stores by chloride with some protection offered by the blood-brain barrier.6

This case report illustrates two unusual problems associated with the use of volatile anesthetic agents in the treatment of severe status asthmaticus. The lack of bronchodilatory response to enflurane is uncommon but should be borne in mind when dealing with asthmatics. Although the bromide levels following halothane anesthesia are normally not high enough to produce severe neurologic symptoms, serum bromide levels should be monitored whenever halothane anesthesia is used for prolonged periods of time.

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Chest Compression-induced Vertebral Fractures*

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Two cases with chest compression-induced thoracolumbar transvertebral fractures are discussed. This is a previously unreported complication of cardiopulmonary resuscitation. Dorsal kyphosis and osteopenia were present in both of these cases. There was no spinal cord injury documented, though the potential for injury and paraplegia exists. Care should be taken to avoid this complication, especially in the elderly with kyphosis; however, adequate compressions to insure support of circulation should be maintained.

Since the 1960s when closed chest cardiac massage was reported,1 chest compression has become an integral part of cardiopulmonary resuscitation. Nationwide training programs by the American Heart Association and the American Red Cross have been effective. In a recent Gallup poll, one in every five adults interviewed had taken a course in cardiopulmonary resuscitation.8

It has been estimated that between 350,000 to 500,000 people die suddenly every year. With the increasing number of providers, there is great potential and opportunity to apply cardiopulmonary resuscitation. In 1976, up to 34 percent of persons suffering cardiac arrests in Seattle, Washington received bystander cardiopulmonary resuscitation.9

Though cardiopulmonary resuscitation is a potentially lifesaving procedure, the force required to insure adequate circulation has been reported to fracture ribs and the sternum.4 With the increased utility of cardiopulmonary resuscitation, there have been numerous reviews published on subsequent complications.6-7 We report two cases with the complication of transvertebral fracture caused by closed chest cardiac massage.

There have been two reports on compression fractures associated with direct current defibrillation of 400 watt seconds,8,8 but none known to us with external cardiac massage-induced transvertebral fractures.

CASE REPORTS

Case 1
A 90-year-old man was admitted for multiple infected decubiti, dehydration, and rhabdomyolysis. His hospital course was complicated by staphylococcal septicemia, acute renal failure, and aspiration pneumonia. There was no history of antecedent trauma. He suffered three cardiopulmonary arrests in succession requiring closed chest compression of 12, 3, and 60 minutes' duration. Chest compressions were performed by nursing and house staff with a board placed under the patient's torso. At autopsy, he was found to have osteopenia, dorsal kyphosis, and a nondislocated transvertebral fracture of the eleventh thoracic vertebral body.

Case 2
A 71-year-old man was admitted for septic shock secondary to a urinary tract infection with a history of chronic ethanol abuse, adult onset diabetes mellitus, and chronic obstructive lung disease. There was no history of antecedent trauma. On lateral chest x-ray film prior to arrest, he was noted to have dorsal kyphosis and osteopenia. No transvertebral fracture was noted. He suffered two cardiopulmonary arrests with chest compression of 30 and 15 minutes' duration performed by nursing and house staff with a board placed under the patient's torso. At autopsy, osteopenia, dorsal kyphosis, multiple rib fractures, and a transvertebral fracture of the first lumbar vertebra were found. There was disruption of the anterior ligaments with preservation of the posterior ligaments, forming a hinge at the level of the vertebral fractures. There was no gross or microscopic evidence of spinal cord injury. Fresh hemorrhage, suggesting recent injury, was noted at the level of the fracture.

DISCUSSION

We describe two cases with chest compression-induced thoracolumbar transvertebral fractures. Neither of these patients had a history of antecedent trauma and it was felt by the pathologists performing the autopsies that the fractures were the result of the resuscitation attempt. Each of these patients had osteopenia and dorsal kyphosis which may increase the propensity toward this complication.

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Chest Compression-induced Vertebral Fractures (Azuma et al)
Osteopenia is a major risk factor for fractures of many types. Dorsal kyphosis can result from anterior compression fractures of the thoracic vertebrae. Dorsal kyphosis may also increase the lumbar lordosis exposing the spine to greater shearing forces during the chest compressions.

There was no spinal cord injury documented in our cases, but the potential for cord damage and paraplegia exists. Compression fractures associated with direct current cardioversion have been felt to be due to muscle contraction stimulated by cardioversion. In compression fractures, the vector of force would be parallel with the long axis of the spine. These patients had transvertebral fractures with the vector of force apparently supplied by chest compression and thus perpendicular to the long axis of the spine.

There is an increasing number of elderly people in the United States. These people are at higher risk for both osteopenia and sudden death. There is also an increasing number of potential providers of cardiopulmonary resuscitation. The incidence of the complication appears small since it has not been reported as yet; however, it may increase with the increasing utility of cardiopulmonary resuscitation.

Transvertebral fracture in itself is not a serious complication; however, impairment of rehabilitation and the serious potential for spinal cord damage should be anticipated and watched for in the elderly patient with dorsal kyphosis who receives chest compression. Treatment of this type of fracture would be controversial, but early recognition is important to prevent possible spinal cord damage from an unstable fracture.

Some form of support for the spine could prevent this complication and could be the focus of further research. Despite the risk of this complication, adequate chest compressions must be maintained to insure support of circulation.

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