Applied anatomy of the spine

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The arteries supplying the vertebral column in the neck arise from the paired vertebral arteries. The thoracic vertebrae are supplied by paired branches of the thoracic aorta which arise from its posterior wall, while the lumbar vertebrae are also supplied by paired arteries which arise from the posterior wall of the abdominal aorta.

Despite these differences in their origins, there is a common pattern of distribution of the arteries on the surfaces and within the substance of each vertebra. These features are most easily appreciated in preparations of the lumbar vertebrae which show each lumbar artery coursing around the waist of the vertebral bodies on each side. Between their aortic origins and the intervertebral foramina, each artery gives off ascending and descending branches on the surface of the periosteum, forming anastomoses with similar branches arising from the adjacent vertebral arteries above and below. From the deep surface of each lumbar artery, centrum branches penetrate to form a grid in the centre of the vertebral body from which vertically orientated tributaries pass upwards and downwards, within the vertebral body, towards the respective vertebral end-plates, giving rise to capillary circulations in the region of the vertebral end-plate cartilages.

These capillaries drain into a horizontal sub-articular collecting vein system which is orientated parallel to each vertebral end-plate and which drains peripherally, but principally posteriorly into the anterior internal vertebral venous plexus within the spinal canal. This plexus surrounds the dural sac and the emerging nerve root sheaths. It is a complex valveless system of veins which is connected with the external vertebral venous plexus at each level in the region of the intervertebral foramina. The lumbar vertebral veins drain into the inferior vena cava while the thoracic vertebral veins drain into the azygos system and the cervical vertebral veins communicate with the venae comitantes of the vertebral arteries and eventually with the jugular system of veins in the neck.

As the principal branches of the lumbar arteries pass backwards, crossing the intervertebral foramina, they give off on each side intraspinal branches both to the floor and roof of the spinal canal, their branches being applied to the periosteal surfaces in an arcuate pattern of distribution, with anastomoses which extend the length of the spinal canal. In addition, intraspinal neural branches arise at this level. These will be described below. The main stems of the arteries proceed backwards applied to the periosteal surface of the lamina and sides of the spinous processes giving intraosseous branches throughout their courses and muscular branches from the outer aspects of each vessel. Corresponding veins accompany the arteries.

The relationships of the arteries which supply the neural arches are constant, each main stem being applied immediately to the pars interarticularis of the lamina on each side.

Damage to the blood supply of the paraspinal muscles may be inflicted either by coagulation with diathermy of the main stem in the region of the pars interarticularis or by applying prolonged pressure through self-retaining retractors to the substance of the muscles themselves. The relationship of each of these vessels, therefore, to the pars interarticularis represents one of the most critical areas in the spine. Damage to the vessel, even a few millimetres anterior to the pars interarticularis, may also inflict irreversible changes on the arterial supply of the cauda equina or spinal cord itself.

Extensive changes in paraspinal muscles may occur as a result of multiple operations or of careless handling of tissues at operation.

The blood supply of the cauda equina and spinal cord arises in the region of the intervertebral foramina outside the dural coverings of each emerging nerve root. Anterior and posterior radicular arteries penetrate dural root sleeves medial to each pedicle. These vessels vary considerably in diameter, but they are present at each vertebral segment in the adult. They course upwards towards the surface of the spinal cord joining respectively the anterior longitudinal arterial channels and the parallel posterior longitudinal arterial channels on the dorsal aspect of the spinal cord. Branches from the surface arteries penetrate the spinal cord and give rise to a capillary circulation within it, from which

Figure 1. A sagittal section from the lumbar spine of an adult cut at the level of the intervertebral foramina through the pedicles of three adjacent vertebral bodies (Spalteholz cleared specimen). The intervertebral venous plexus can be seen surrounding the emerging nerve roots related to the upper two intervertebral discs. Note the pattern of venous drainage from the dorsal root ganglia joining the posterior internal vertebral venous plexus. Note also the large pedicle veins which join the tributaries of the internal vertebral venous plexus, well shown in the two lower pedicles

The main stem of the posterior branches of two lumbar arteries are seen at the right of the photograph accompanied by venae comitantes. These vessels are constant lateral relations of the partes interarticulares. Reproduced from Crock and Yamagishi 1986.

veins emerge in patterns which contrast with the distribution of arteries on the surface of the spinal cord. There is a central venous channel both on the anterior and posterior surfaces of the spinal cord, these channels being connected by circumferentially orientated vasa corona. Radicular veins then course distally along each nerve root to penetrate the dural nerve root sleeves in the axillae where they join tributaries of the internal vertebral venous plexus (Figure 1). A valve-like mechanism exists between the intradural and the extra-dural veins. This accounts for the centrifugal direction of flow of the blood in the veins of the spinal cord and cauda equina. The critical point, therefore, in the venous drainage of the spinal cord and cauda equina lies in the region of the axilla of the nerve root sheath at each level. Damage inflicted on veins in this area may result in serious neurological deficits.

Applying these anatomical facts to clinical problems, attention is focused first on foraminal and nerve root canal stenosis. This is most commonly seen in isolated disc resorption, a condition which leads progressively to loss of disc height, the appearance of a Knuttson sign on plain radiographs and ultimately to distortion of the affected nerve root canals and intervertebral foramina bilaterally. This results in venous obstruction around the nerve roots causing symptoms of buttock and thigh pain which is often bilateral and aggravated by standing or sitting. The principal problem of venous obstruction in this condition is also found in some cases of lumbar canal stenosis where the pathology affects the roof of the canal due to facet joint hypertrophy. In some of these cases, however, where multilevel canal stenosis is present, there is also an important central canal stenosis which may interfere with the arterial circulation of the cauda equina and give rise to the paralytic symptoms of cauda equina claudication.

Spinal canal decompression was formerly achieved by central laminectomy. Applied anatomy now indicates that it is better carried out by multilevel interlaminar decompressions with preservation of the spinous processes and supraspinous ligaments so that the lumbo-dorsal fascia may be reattached to these midline structures at the conclusion of the decompression procedure.

This reduces postoperative hemorrhage. It avoids the problem of bow stringing of the paraspinal muscles. It preserves the normal lumbar lordosis and enhances the return of function of the extensor mechanism of the spine which is dependant on the integrity of the lumbo-dorsal fascial attachments to the supraspinous ligaments.

In cervical myelopathy, the stenotic process almost certainly interferes with the central arterial supply of the spinal cord. This is best treated, in most instances, by anterior decompression of the cervical canal.

Finally, in understanding the very disabling condition of internal disc disruption which gives rise to discogenic low back pain, an understanding of the vertebral body circulation is essential, first of all in inter-

preting the clinical syndrome and secondly from a practical point of view, making use of the arterial blood supply of the vertebral bodies to vascularize interbody grafts.

References

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