Postmortem angiographic study of degenerative vascular changes in arteries supplying the cervicobrachial region

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Abstract

Objectives—To study the prevalence of degenerative changes in the arteries supplying the cervicobrachial region, and their relation to cervical disc degeneration.

Methods—Fifty postmortem aortic arch angiographies were evaluated for occlusions and variations in the diameter of the vertebral arteries and thyro- and costocervical trunks, as well as for tortuosity, average diameter and the highest cervical level to which the ascending cervical artery, an upward continuation of the thyrocervical trunk, and the deep cervical artery, an upward continuation of the costocervical trunk, ascended.

Results—Localised segmental narrowings, usually situated close to the ostia of the arteries, were common, whereas total occlusions were rare. Thirty (60%) of the subjects showed a segmental narrowing at least in one of the six arteries analysed, while only two (4%) showed an occluded artery, which in both the cases was the thyrocervical trunk. Narrowings were most common in vertebral arteries, followed by costocervical and thyrocervical trunks. Segmental narrowings, as well as general tortuosity of the arteries, increased with age. It was also found that ascending and deep cervical arteries did not run as high up in the posterior neck muscles in older people as in younger ones. Twenty three subjects with marked cervical disc degeneration showed on average 2-3 arteries with segmental narrowings, while the corresponding figure for twenty seven subjects without disc degeneration was 0-6. Both the segmental narrowings and the disc degeneration, however, were strongly associated with age, and thus the causality between the former two remained unclear.

Conclusion—The study showed that degenerative changes are common in the arteries supplying the cervicobrachial area, indicating that impaired blood flow might play a part in some cervicobrachial disorders.


Cervical disc degeneration, as well as poorly defined cervicobrachial pain syndromes, belong to those musculoskeletal disorders that are common in the population, but whose possible aetiological and pathological mechanisms are by no means clear. These disorders have heterogeneous symptoms such as pain, tenderness, stiffness and fatigue felt diffusively over the posterior neck and shoulder area, and exacerbated by physical exertion. Though many research workers have suspected local ischaemia as one possible explanation for the symptoms, we could find no reports concerning the condition of arteries supplying the neck-and-shoulder region. Atherosclerosis, manifesting itself in middle age or even earlier, and being very common in carotid and vertebral arteries, might also affect the thyrocervical and costocervical trunks, the main feeders of the cervicobrachial region. Branches of these trunks, together with branches of the vertebral arteries, supply the cervical spine, as well as the musculature of the neck and upper shoulder regions.

Ageing of the vascular system does not occur simultaneously in all the arteries; some branches of the subclavian artery are more often affected than others. Stenosis of the vertebral artery at its origin from the superior aspect of the subclavian artery is a well-known atherosclerotic manifestation, whereas the internal mammary artery, leaving the subclavian artery from its lower surface opposite the vertebral artery, usually escapes arterial disease. The fate of the thyro- and costocervical trunks, originating from the subclavian artery just after the orifice of the vertebral artery, is unknown.

To determine the general condition of the arteries supplying the cervicobrachial area, we investigated the prevalence of degenerative changes in the vertebral arteries and thyro- and costocervical trunks. We also analysed the highest cervical level to which the upward continuations of these trunks, the ascending cervical artery from the thyrocervical trunk and the deep cervical artery from the costocervical trunk, ascended. Furthermore, cervical disc degeneration was assessed to learn whether it had any relationship with arterial disease.

Materials and methods

Necropsy

Aortic arch angiography was performed on 55 cadavers at the Department of Forensic Medicine, University of Helsinki. Five of the cases had to be omitted from the study due to
This technique of injection will result in the filling of arteries down to 0.1 mm in diameter. This angiographic method is in routine use in postoperative necropsies at the Department of Forensic Medicine, University of Helsinki. It is described in detail elsewhere. When the contrast medium had solidified, the trachea, oesophagus and thyroid gland were removed en bloc with their contrast-filled vessels in order to provide more selective angiographies of the musculoskeletal structures of the cervical region. The vertebral arteries and the thyrocervical and costocervical trunks, as well as their upward continuations; the ascending cervical artery and the deep cervical artery, were then examined in anteroposterior and lateral radiographs. Other branches of these trunks could not be analysed from these two radiological projections.

In some cases the first parts of the thyrocervical and costocervical trunks were not clearly seen in angiograms due to their location on the dorsal side of the subclavian artery or behind each other. In these cases (7 subjects), after the angiography, the subclavian artery was divided and the vulcanised cast from it and from the first parts of the vertebral artery and thyro- and costocervical trunks removed for macroscopic analysis for narrowings (fig 1).

EVALUATION OF ANGIOGRAMS

The following characteristics were recorded from the angiograms: occlusions, variations in the diameter of the vessel (localised segmental narrowing of the contrast-medium pillar), tortuosity, average diameter; and also for the ascending and deep cervical arteries, the highest cervical level either one of them reached.

Variations in the diameter of the vessel were determined for the vertebral arteries and for the thyrocervical and costocervical trunks, but not for the ascending cervical and deep cervical arteries, because the small diameter of these vessels made assessment difficult and unreliable. If the first parts of the analysed arteries were not distinctly visible in angiograms, the casts when removed were used for analysis. Narrowings to no less than one fifth of the lumen were recorded from the casts, equalling the smallest narrowings visible in the angiograms.

Tortuosity of the vertebral, ascending cervical and deep cervical arteries was classified into three categories: 1 = straight; 2 = slightly tortuous; 3 = tortuous. Straight and distinctly tortuous vessels were first separated into categories 1 and 3. The borderline cases with probable or mild tortuosity difficult to classify as either straight or distinctly tortuous formed category 2. Because the degree of tortuosity was in most cases symmetrical, the right and left sided arteries were analysed jointly.

The average diameter of the vertebral, ascending cervical and deep cervical arteries was graded into three categories: 1 = normal; 2 = slightly narrowed; 3 = narrow. Normal and distinctly narrow vessels were first separated into categories 1 and 3. The borderline cases

technical failure of the angiography, so altogether 50 bilateral cervical angiographies, performed on 40 men and 10 women, were analysed. Eligible cadavers had not died of an injury to the head or neck region, but in other respects the material was unselected. Their mean age was 48.8 years; range 16–76 years. The angiographies were carried out in connection with routine necropsies 1–9 days after death.

Drug or alcohol overdose, or suicide was the cause of death in 46% (23) of the cases, coronary artery disease in 38% (19), other vascular diseases in 6% (3), and a variety of single diseases in 10% (5).

ANGIOGRAPHIC TECHNIQUE

The cervical arterial system was bilaterally investigated by aortic arch angiography. The aorta was transected from its ascending part, cannulated with a mouthpiece, and the common carotid and internal mammary arteries were clamped. The subclavian arteries were clamped beyond the origin of the thyrocervical and costocervical trunks. The contrast medium, consisting of liquid silicone rubber (Silicon Kautschuk RTV-Vergussmasse K, Wacker Chemie Gmbh, Munich, Germany) made radiopaque with 20% lead oxide, mixed with 2% solidifier (Haerter T), was injected under a pressure of 150 mmHg into the aorta to visualise the cervical arterial system. This mixture solidifies into a cast within two hours.
with probable or mild narrowing formed category 2 (fig 2).

There is a large anatomical variation in the upward course of both the ascending cervical and deep cervical arteries. Usually both ascend in the back of the neck as high as the second cervical vertebra and anastomose with branches of the vertebral and occipital arteries and also with each other.\textsuperscript{14-17} The angiograms gave an impression that frequently only one of them was large enough to be visible in the upper part of the neck. Thus to analyse the highest cervical level to which these arteries ascended, only the value for the artery ascending the highest on each side of the neck was recorded. The level was graded into three categories: 1 = above or at the level of the spinous process of the second vertebra; 2 = between the spinous processes of the second and third vertebrae; 3 = below the spinous process of the third vertebra (fig 3).

EVALUATION OF CERVICAL DISC DEGENERATION

Anteroposterior and lateral plain radiographs were taken before necropsy to examine whether the cervical discs were degenerated or not. Due to rigor mortis the lateral view of the lowest part of the cervical spine was often difficult to image. After necropsy, when the anterior block (trachea, oesophagus and thyroid gland) was routinely removed, the

Figure 2 Examples used in estimating the tortuosity and the average diameter of vertebral (broad arrows), ascending cervical (smaller arrows) and deep cervical (curved arrows) arteries. In A the tortuosity of the arteries is classified as straight, in B the vertebral arteries are slightly tortuous and ascending and deep cervical arteries are tortuous, in C the vertebral arteries are tortuous. In A the average diameter of the arteries is normal, in C the deep cervical artery on the left side is slightly narrowed and ascending cervical artery is narrow; on the right side these arteries are missing.

Figure 3 Examples for estimating the highest level of ascending or deep cervical arteries in the posterior part of the neck. In A one of the arteries on each side of the neck ascends above the second cervical vertebra, in B an artery on one side ascends above the second vertebra, whereas on the other side the corresponding artery does not reach even to the spinous process of the third vertebra.
lower part of the cervical spine became more visible in lateral angiograms, but then the contrast-filled arteries hampered evaluation of the cervical spine. However, the anterior parts of the vertebral bodies were visible for analysis, and thus anterior osteophytes were used to assess cervical disc degeneration. If any anterior osteophyte was present the cervical spine was regarded as degenerated.

**STATISTICAL ANALYSIS**

To analyse categorial variables, Pearson’s linear trend test was used. Logistic regression analysis (BMDP, LR) was used to test the association between arterial disease and cervical disc degeneration.

**Results**

The vertebral arteries and the costocervical trunks showed no total occlusions of the arterial lumen, whereas the thyrocervical trunk was bilaterally occluded at its origin in one case (a woman aged 51 years), and unilaterally in one case (a woman aged 64 years).

Segmental narrowings were common; thirty (60%) of the subjects had at least one artery showing local narrowings(s). The youngest person showing a segmental narrowing (in this case in a costocervical trunk) was a woman aged 30 years. Narrowings were most commonly situated at the orifices or in the proximal sections of the arteries. Up to the age of about 50 years they were quite rare, but after that age they increased considerably with age. Subjects up to the age of 50 years showed on average 0-4 arteries with narrowings, while all subjects above the age of 61 showed one or more arteries with narrowings. Subjects over 60 showed on average 2-8 arteries with segmental narrowings. The distribution of arteries with segmental narrowings is shown in Table 1.

The tortuosity of the arteries also increased with advancing age (0-000 < p < 0-002), being most obvious in the deep cervical arteries (table 2), whereas the average diameter of the arteries did not show statistically significant changes with age. Vertebral arteries showed distinct unilateral general narrowing in only two persons, aged 42 and 56 years. General narrowing of the arterial lumen was more common in the ascending and deep cervical arteries. However, if one of these arteries was narrow, the other one on the same side of the neck was often wider, probably compensating for the narrow one (table 3).

In 30 (60%) of the subjects the ascending or deep cervical arteries ascended on both sides above or to the level of the spinous process of the second cervical vertebra, while in 11 (22%) of the cases these arteries on one or both sides were visible only between the spinous processes of the second and third cervical vertebra, and in nine (18%) of the cases they seemed to end even below this level (table 4).

The youngest person showing these arteries running bilaterally between the second and third cervical vertebra was a 38 year old man,
and the youngest person showing these arteries ending bilaterally below the third cervical vertebra was a man aged 63 years. The arteries ascended higher in younger than in older people (p = 0.03).

Twenty three (46%) of the subjects (mean age 61.5, range 44–76) showed cervical disc degeneration (anterior osteophytes) in at least one intervertebral level, while 27 (54%) of the subjects (mean age 38.0, range 16–59) exhibited no anterior osteophytes. Disc degeneration increased with age, so that all the subjects above the age of 59 years showed anterior osteophytes. In logistic regression analysis (BMPD, LR) the causality between arterial disease and disc degeneration remained unclear due to the strong correlation of both of these factors with age.

Discussion
The study showed that degenerative changes were common in the arteries supplying the cervicobrachial region. Localised segmental narrowings of the arteries, as well as general narrowing and tortuosity of the vessels have an effect on the amount of blood running through them. Impaired blood flow may give rise to ischaemic symptoms, especially during exertion, when extra nutrition is needed. It can be logically assumed that some of the cervicobrachial complaints, such as fatigue and pain exacerbated by physical strain, might be ischaemic symptoms.

Several investigators have presented the theory that ischaemia might be a significant factor in occupational cervicobrachial disorders. Fassbender and Wegner based their hypothesis regarding prolonged ischaemia as an aetiologal factor on detection of degenerated mitochondria and increased glycan deposits in biopsies from the trapezius muscles in patients with muscular rheumatism. Bjelle et al showed that ischaemia of the supraspinatus occurred during assembly-work tasks, explaining why cervicobrachial symptoms were so frequent in these workers. Larsson et al found atrophic muscle fibres and reduced local blood flow to be associated with chronic myalgia of the trapezius muscle. Lindman et al reported that patients with chronic trapezius myalgia had a lower capillary: muscle fibre area ratio than did the referent group. All these studies point to a possible relationship between deficient nutrient supply and cervico-brachial pain syndromes.

Occulsive arterial disease, causing claudication pain, is frequently found in the arteries supplying the lower extremities. Obliteration of lumbar arteries, owing to either atheromatous lesions in the abdominal aorta or congenital hypoplasia of the arteries, has an association with low back pain. Further studies on the relation between atherosclerotic changes in the abdominal aorta and lumbar disc degeneration in an unselected adult cadaver showed that disc degeneration increased with advanced atherosclerotic manifestations in the abdominal aorta, and especially with stenosis of the ostia of lumbar arteries above and below the disc. The same ischaemic mechanism may be in action in the cervicobrachial region, as well. In this area, however, physical requirements are usually less demanding, explaining why symptoms are, as a rule, less disabling than are lower limb or low back symptoms.

The significant observation in this study was that the arteries supplying the cervicobrachial region were frequently affected by arterial disease. Degenerative changes in the vertebral arteries were found to be consistent with previous studies whereas no studies on costocervical and thyrocervical trunks were available for comparison from previous reports. However, these arteries were affected almost as frequently as the vertebral arteries, the finding being not unexpected, because their origin on the superior aspect of the subclavian artery probably makes them as vulnerable to arterial disease as is the vertebral artery.

Although our study indicates that blood supply to the cervicobrachial region may be compromised, the cross-sectional nature of this study leaves cause and effect relationships unclear, and the relationship between blood supply and cervicobrachial disorders remains hypothetical. Clinical investigations are needed for further understanding of the significance of blood supply for musculoskeletal disorders in the posterior neck and shoulder region.

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References
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