Expert's comment concerning Grand Rounds case entitled “Vertebral artery injury and severely displaced odontoid fracture: the case for early reduction” (by M.P. Sullivan, J.D. McCormick, V. Arlet)

F. Kandziora · A. Langheinrich

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This is an interesting case report describing an excellent clinical result achieved by indirect decompression of the vertebral artery by “early” reduction with traction in a trans-odontoid atlanto-axial luxation fracture [1].

The trans-odontoid luxation fracture is a highly unstable traumatic lesion of the atlanto-axial complex most often associated with an Anderson type II fracture of the odontoid (Fig. 1). In many cases, this luxation can already be suspected on the conventional X-rays by the position of the atlas and the significant dislocation regularly exceeding the complete width of the odontoid (Fig. 1a, b). In addition, it is characterised by CT-confirmed unilateral- or bilateral jumped (Fig. 1c, d) and sometimes even locked lateral

atlanto-axial facet. In most cases, the jumped facets can easily be reduced by slightly closed axial traction. Sometimes, however, especially in elderly patients with severe degenerative changes or in associated fractures of the lateral atlanto-axial joints, open reduction might be mandatory. Although neurological deficits like brainstem lesions in patients who have survived the initial trauma are rare, vascular lesions of the vertebral artery are often associated with that injury. Due to the high ligamentous instability after reduction based on the rupture of the capsule of the lateral atlanto-axial facet joints (the capsule of medial atlanto-axial joint—odontoid-atlas joint—stays intact), the ligamentum flavum, the longitudinal fascicle, and sometimes even the atlanto-occipital membrane, an isolated anterior odontoid screw fixation is often biomechanically insufficient. Therefore, posterior atlanto-axial stabilisation and fusion in the Magerl or Goel/Harms technique (Fig. 1e, f) are generally recommended.

The diagnostic modalities and the treatment protocol, especially the timing of the reduction, should be discussed.

Since the introduction of multi-slice CT (MS-CT), a lot of work has been done to identify vascular injuries in trauma patients, especially in the cervical spine [2–4]. Because of these well-defined imaging modalities (MS-CT and conventional angiography) and their clinical relevance in trauma patients, the added contribution of MRI-Angiography (MRI-A) is not well conveyed in terms of specificity. However, in this case, the MRI-A was used to diagnose the occlusion of the vertebral artery. In general, the MRI-A is associated especially in trauma cases with a high rate of false positive findings like the here-described occlusions of a vertebral artery. In addition, MRI-A has the tendency to overestimate the severity of a vascular stenosis, is not precise enough to determine intimal tears, and is prone to artefacts and costs time and money. Therefore, the

F. Kandziora (✉)
Zentrum für Wirbelsäulenchirurgie und Neurotraumatologie,
Berufsgenossenschaftliche Unfallklinik, Friedberger Landstraße
430, 60389 Frankfurt am Main, Germany
e-mail: Frank.Kandziora@BGU-Frankfurt.de

A. Langheinrich
Zentrum für Bildgebende Diagnostik, BG Unfallklinik,
Frankfurt, Germany

Fig. 1 An 84-year-old female, who had a simple fall at home, presented with trans-odontoid atlanto-axial luxation with typical radiographic appearance. **a** Significant dislocation on conventional X-ray, **b** CT scans, **c** luxation of the lateral atlanto-axial joint on

reconstruction, **d** axial images, **e** postoperative conventional X-ray after C1/2 fusion according to Goel/Harms and **f** CT reconstruction of the reduction

determination of arterial injury only based on MRI-A is not well supported.

The golden standard to diagnose vascular lesions currently is the digital subtraction angiography (DSA). This is especially important in trauma cases, because it is often difficult to differentiate spasm from true arterial injury at MRI or CT imaging as both may appear as focal or diffuse narrowing. Diagnostic conventional angiography may be helpful in these cases by allowing the arterial spasm to resolve and to differentiate spasms from true arterial injuries. The DSA, however, is an invasive procedure that needs an adequate setup, an experienced examiner and also a lot of time. In addition, it only results in 2D images and is associated with a significant complication rate due to its invasiveness. Hence, its value is very limited in acute trauma cases.

DSA has nowadays widely been replaced by computed tomography angiography (CTA), especially in the trauma setting (Fig. 2). Computed tomography (CT) is in anyway

the standard modality to evaluate spine fractures. If a spine fracture is suspected to be associated with a vascular lesion, it is quite simple to add some contrast media during the initial examination and to perform an additional CTA. The CTA can in this situation be done without delay, which is in clear contrast to the MRI-A. Further, the CTA is simple, reliable, reproducible, and precise—even in details like intimal tears—, very quick, cost-effective and delivers 3D images. Finally, it allows the determination of an exact relation between the bony and vascular anatomy, which is necessary, especially in the upper cervical spine to plan screw placement. Hence, it is in our hands to clearly adopt the preferred modality to diagnose vascular lesions associated with spine fractures.

Is an MR scan necessary in the described case? It might be necessary to protect yourself depending on the medico-legal environment in which you are working by documenting the status prior to intervention. However, I do not think it is necessary to plan the treatment if the patient is

Fig. 2 Typical CT angiography of the cervical spine. **a** Axial slides, **b** 2D reconstructions showing the relation between vessels and bone, and **c** overview of the vessels

conscious and neurologically intact, like in this case report. Only if the patient is unconscious or if there is a neurological deficit that does not correspond to the level of the instability, an MRI is mandatory. In any other case, the MRI might delay the most important part of the treatment, which is the closed reduction.

A basic principle in the treatment of any type of dislocated skeletal fracture associated with a vascular lesion is the immediate reduction. I completely agree with the authors that a prompt reduction is the basis for the restoration of the blood flow and I personally believe that is especially true for the cervical spine. But what is a prompt or early reduction and how should it be performed?

The reduction under traction, which was performed by the authors, is a reliable and effective treatment. It allows a gradual and gentle patient self-controlled reduction of the fracture, at least in a conscious patient it is safe because the conscious patient can immediately report about a neurological deterioration. The only drawback of this procedure is that it takes a lot of time (in this case 12 h), maybe being too late to establish a reperfusion of the artery.

It is common sense that the longer the occlusion of the artery persists, the lower the probability that the flow of the artery is restored. An alternative to the reduction under continuous traction in many hours is the immediate or emergency reduction in minutes by “experienced hands”. This manual reduction offers the clear advantage that the occlusion of the artery can be addressed earlier, however, the disadvantage that the reduction might potentially be less controllable.

Authors preferred treatment

The initial evaluation of the patient with a standard X-ray would be suspicious for a trans-odontoid atlanto-axial

luxation fracture due to the high degree of dislocation. In this case, we would have ordered a CTA that of course also shows the bony anatomy. In the neurological intact patient, we would not see the necessity to perform an additional MRI. Waiving the MRI ensures that we are not delaying the treatment. After confirming the vascular lesion, we would have brought the patient directly to the OR and under general anaesthesia we would not only have done the manual reduction but also the posterior atlanto-axial stabilisation as an emergency procedure, hoping that we would have achieved the same result as our colleagues, only a little bit quicker.

Finally, it is obvious that in details our approach might differ, but in general, we would have treated the patient based on the same principles: “early reduction and stabilisation”. I congratulate the colleagues to the excellent result of their treatment and the patient for finding such excellent surgeons.

Conflict of interest None.

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