Review

The Overlooked Significance of the Ponticulus Posticus in Whiplash Patients

Leonard Vernon *

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The Overlooked Significance of the Ponticulus Posticus in Whiplash Patients

Leonard Vernon

Sherman College of Chiropractic, Spartanburg, SC 29304; drvernonchiro@aol.com

Abstract

Because of its anatomical complexity, the cervical spine is highly susceptible to injury, especially the blunt acceleration/deceleration trauma of which the most frequent mechanism, is "whiplash", commonly referred to as Whiplash Associated Disorder (WAD). Despite this knowledge the significance and complexity of whiplash injuries are widely underestimated. This underestimation of the significance of this injury is the widely held belief that it is a benign self-limiting soft tissue injury that frequently has monetary gain attached. Estimates are that 10% of all spine injuries are related to WAD with 40% of these involving the *Atlas* (C1) and *Axis* (C2). This negative framing of the injury which has largely been shaped by the insurance industry rather than by clinicians frequently causes medical providers to view the injury with skepticism, despite estimates showing that approximately 50% of whiplash patients suffer chronic neck-related disability. Adding to the problem faced by clinicians are the more recently imposed guidelines for diagnosing and treating acute whiplash, especially in the area of imaging that has placed both the provider and the patient at increased risk.

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1. Introduction

In 1955 Severy et al. reported that motor vehicle collisions, even at 20 km/h, (Approximately 12 mph) can cause cervical spine injury and related symptoms [1]. Nonetheless, the insurance industry has been able to codify *no damage, no injury* with the MIST (Minor Impact Soft Tissue) protocol. MIST is an insurance industry claims-handling strategy that assumes, based on low-speed impact, that minimal vehicle damage (often >$1000) equals little to no bodily injury. It is commonly used to flag claims for potential fraud. Adjusters often use this method to deny or drastically reduce payouts, regardless of medical evidence, but it has been widely criticized by medical professionals as scientifically invalid [2].

Because of the pervasive dissemination of misinformation, as well as the pressure to reduce unnecessary imaging imposed by governmental regulatory agencies and professional associations—ostensibly to minimize radiation exposure and healthcare costs [3] despite evidence suggesting that blanket reductions in cervical spine imaging may compromise patient safety and clinical outcomes it continues to be widely promoted. Clinicians are confronted by a complex clinical scenario wherein strict adherence to guidelines designed to reduce imaging could result in missed diagnoses and/or delayed treatment of significant cervical injuries. These guidelines are purported to rely on settled science, and while unnecessary radiation exposure should be of concern, the issue regarding the dangers of X-rays is far from settled. Arone et.al noted "*a threshold level of radiation exposure that leads to adverse health effects has not, and likely cannot be, determined. The process of hormesis exists to repair bodily damage from radiation exposure; however, the extent to which this mitigates risk from exposure is also inconclusive*" [4]. Oakley et al. have labeled this X-ray hesitancy as "radiation fearmongering" [5].

When a patient who has sustained an acute cervical spine injury is summarily dismissed by an emergency room or family physician because of insufficient damage to the vehicle or because there

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are no neurological deficits on examination, without first obtaining a minimum 3-view X-ray series (although a 5-view series, including flexion and extension, if safe to perform and should be included), this puts both the clinician and the patient at risk. Unfortunately, in the absence of neurological findings, this omission of imaging has become more frequent. While it is assumed that the neurologically intact patient has a low-level risk for fracture, this is not the only information that is available on a plain cervical spine X-ray. To fail to obtain post trauma X-rays of the cervical spine is to ignore often overlooked or ignored anatomical variants and other structural findings that indicate serious injury.

Davis noted that "*During injury, there is a sudden unexpected stretching force of the skeletal muscles induced by a barrage of impulses from receptors in muscles and joint capsules that travel to the central nervous system …this is known as the jolt syndrome*" [6]. The effects of jolt syndrome can cause cervical symptoms related to whiplash-type trauma due to a stretching of the vertebral artery during injury [7]; however, on physical examination, the patient appears neurologically intact. Frequently visualized on the lateral cervical X-ray as is a loss of the lordotic curve, this is often dismissed as "muscle spasm" when, in fact loss of cervical lordosis has been shown to alter vertebral artery hemodynamics [8]. Other studies have determined that cervical curvature straightening and inverse arch are the causes of atlantoaxial instability: the smaller the cervical curvature, the more serious the atlantoaxial instability [9].

Another example of what the literature describes as "a relatively common anatomic variation in the atlas vertebra," but with the potential to cause significant pathology, is the ponticulus posticus (PP) [10]. Under the current guidelines that eliminate cervical spine X-rays in the neurologically intact patient, it would be missed.

2. Definition of PP

A PP can be classified into four distinct forms:

(1) A complete PP is a continuous bridge that extends from the posterior aspect of the lateral mass to the anterior aspect of the posterior tubercle.

(2) A partial PP is one that does not extend fully from the posterior lateral mass to the posterior tubercle.

(3) A partial upper PP is one that extends partway from the posterior aspect of the lateral mass toward—but not touching—the posterior tubercle.

(4) A partial lower PP is one that extends partway from the posterior tubercle toward—but not touching—, the posterior aspect of the lateral mass.

In this paper, the abbreviation PP is used to refer to any of the above forms.

Some of the earliest writings on PP date back to 1906 and the work of the Dutch anatomist Louis Bolk [11], and physical evidence of PP has been found in human skeletons from the 12th century [12]. PP, also known as *arcuate foramen*, is a bony bridge which arises from the lateral mass of the atlas, transforming the groove of the vertebral artery into a canal on the posterior arch of the atlas (Figure 1). The medical literature describes the presence of PP as an anatomical variant originating with the ossification of the lateral segment of the posterior atlanto-occipital ligament. Its significance lies in its relationship with the vertebral artery. The vertebral artery travels through the transverse foramen of the atlas and follows the posterior arch to pass through the fibro-osseous foramen toward the posterior atlanto-occipital membrane, where it then penetrates the vertebral canal. [13] (Figure 2).

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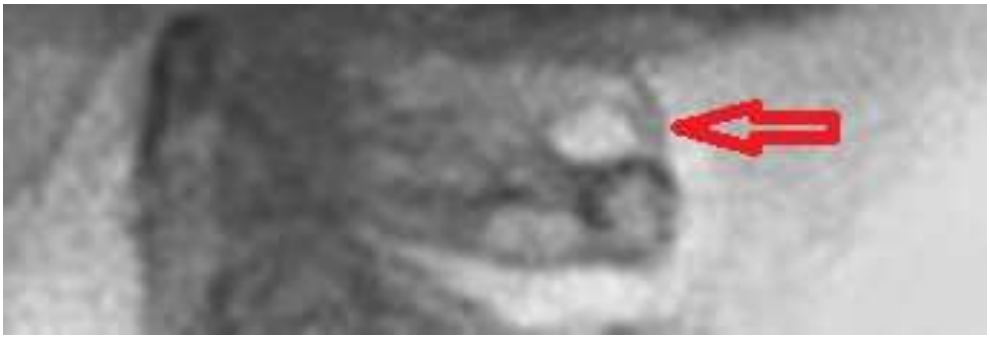

Figure 1.

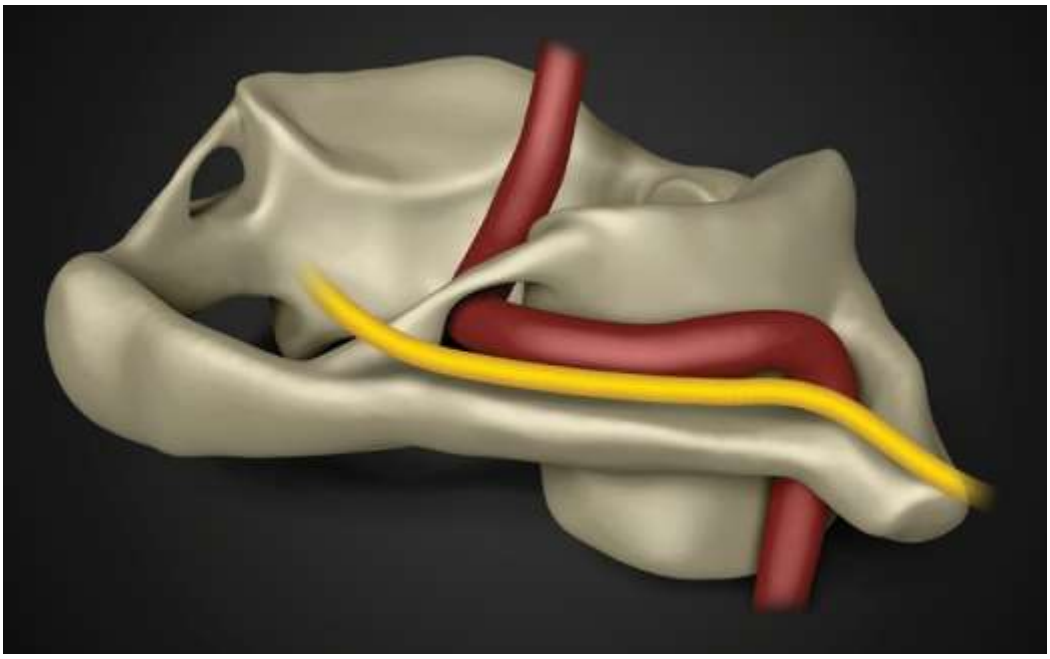

Figure 2. Used by permission of Matthew R. Skalski, DC, DACBR.

The presence of the PP variant has been implicated in a number of what appear to be unrelated and often unexplained symptoms including vertebral artery elongation, dissection, dental symptoms (including those of temporomandibular joint), visual disturbances accompanied by headache and neck pain [14], and hearing loss [15]. This collection of symptoms, often referred to as *Barré–Liéou syndrome*, is thought to be caused by the alteration of the blood flow within the vertebral arteries and an associated disturbance of the periarterial nerve plexus causing hyperactivation of the autonomic nervous system, typically due to trauma [16,17].

From an evolutionary standpoint, PP is commonly present in monkeys and in quadrupeds, in which the superior margin of the posterior bridge provides a larger area for the attachment of the posterior atlanto-occipital membrane, helping to support the weight of the head. In humans, this support has come to be supplied by the superior articular facets of the atlas, which has caused the PP bridge to essentially disappear [18].

3. Dangers of Whiplash-Associated Disorder and the Ponticulus Posticus

While motor vehicle crashes are not the sole cause of whiplash-associated disorderthey are by far the most common and are usually accompanied by a collection of symptoms arising after acceleration injury due to an unaware victim being struck in a stationary vehicle, usually from behind. Symptoms frequently include neck pain, dizziness, and headaches, which may persist up to months or years after the accident. During a rearend collision, the cervical spine is subjected not only to hyperextension and hyperflexion of the spine but also to *axial* rotation and shear forces [19].

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Hasan et al. noted that the vertebral artery is particularly vulnerable to compression during extreme rotation of head and neck movements and that the presence of PP may further compromise the caliber of an already-stretched vertebral artery [20] (Figure 3). Additionally, Cushing et al. found there to be an association between PP and the tethering of the vertebral artery within it, contributing to its dissection from repetitive trauma with movement of the neck [21]. According to Tubbs et al., PP may cause external pressure on the vertebral artery as the latter passes through it to the foramen magnum [22].

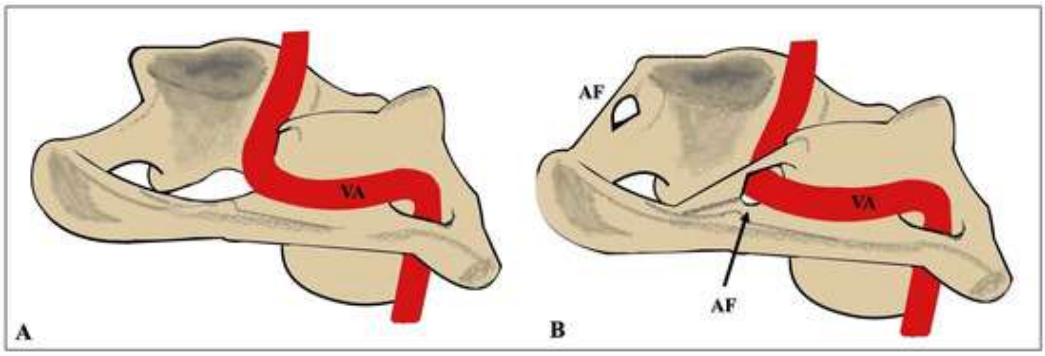

Figure 3. Schematic representation of the typical course of the vertebral artery (VA) at the level of the first cervical vertebra (**A**) and the course when the arcuate foramen (AF) is present (**B**). (Used by permission Maria Piagkou, MD).

In 1997, Nibu et.al. quantified vertebral artery elongation due to whiplash using an in vitro simulation. Their findings suggested that this elongation during trauma constitutes the pathomechanism for certain aspects of the whiplash symptom complex and that during whiplash, mechanisms other than simple flexion/extension of the cervical spine cause arterial elongation [23].

Although it has been demonstrated that whiplash can cause intracranial vertebral artery dissection, in isolation or combined with extracranial extension, even in the absence of PP [24], Closs et al. suggested that there is an increased likelihood of this occurring if the foramen diameter is reduced, such as in cases of PP, where ischemic compression of the vertebral artery can occur, resulting in a reduction in cerebral blood flow [25]. This finding has been confirmed by Gul and Atik [26]. Additionally, research indicates that ponticulus posticus is actually a significant risk factor for the development of type 2 odontoid fractures following cervical trauma [27].

Given what is known, the finding of a PP on a plain-film X-ray has several implications in the treatment of the whiplash patient, requiringcareful evaluation and awareness by the clinician. This is especially true for those practitioners who practice a form of manual therapy, such as chiropractors. While the exact percentage of the patients who suffer a whiplash injury and receive treatment from a chiropractor is not available, studies show that chiropractors do treat a significant proportion of whiplash patients [28].

Given the very high number of manipulations performed annually, the absolute risk for arterial dissection is extremely low [29]. Nonetheless, for the chiropractor, the paramount concern is the risk of vertebral artery injury. High-velocity, low-amplitude (HVLA) manipulation of the cervical spine requires a comprehensive risk assessment to identify suitable patients and minimize potential complications, including vertebral artery injury [30]. While the presence of a PP is not an absolute contraindication in chiropractic care, chiropractors may choose to alter their cervical adjusting technique or limit the amount of force introduced with the adjustment.

For the emergency room clinician, the need for—at minimum—a 3-view cervical spine X-ray examination should be the rule of thumb, even in the presence of a normal neurological examination. While these examinations cannot only rule out osseous pathology, they can help determine the severity of the ligamentous injury or the underlying congenital abnormalities, which could influence the type of treatment the patient receives.

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