

Benjamin Alcock and the Pudendal Canal

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ABSTRACT

The anatomy of the pudendal nerve is complex and difficult to visualize. Entrapment of the pudendal nerve is believed to occur in a canal, the pudendal canal or Alcock's canal, yet in the literature this term is used to refer to several different anatomic locations. We present a brief history of Benjamin Alcock, and we compare Alcock's original description of the pudendal canal with our findings from a cadaveric study. It is concluded that Alcock's canal for the pudendal nerve, as Alcock described it related to the pudendal artery, should be that portion of the pudendal nerve within the obturator internus fascia. This definition now permits future medical and surgical approaches to use the appropriate terminology for this anatomic location.

KEYWORDS: Alcock's canal, pudendal nerve, pudendal nerve entrapment

The anatomy of the pudendal nerve is complex and difficult to visualize (Fig. 1). Similar to median nerve compression in the carpal tunnel at the wrist, entrapment of the pudendal nerve is believed to occur in a canal, the pudendal canal or Alcock's canal, but the pudendal nerve also is described as being entrapped between the sacrospinous and the sacrotuberous ligaments. It has been difficult to learn if "Alcock's canal" includes both of these anatomic sites or not. Knowledge of the exact topography of the pudendal nerve and its branches in relation to this canal and other entrapment sites is important to define anatomic sites that could be a location for nerve entrapment and provide uniformity in surgical descriptions of the symptoms and treatment of pudendal nerve entrapment. We present a brief history of Benjamin Alcock, and we compare Alcock's original description of the pudendal canal with our findings from a cadaveric study.

METHODS

Original manuscripts of Benjamin Alcock's biography and his description of the pudendal canal were obtained

from the Beinecke Rare Book and Manuscript Library and the Historical Medical Library at Yale University, New Haven, Connecticut. Permission to use these materials for publication was granted by these libraries.

Dissections were done on four male and one female formalin-fixed cadavers and one fresh male cadaver. The dissections of the pudendal canal were performed using three different approaches: posterior, anterior, and a medial approach after hemi-section through the pelvis.

RESULTS

Biography of Benjamin Alcock

Benjamin Alcock was born in May 1801 in Kilkenny, Ireland. He was the son of Deborah Prim and Dr. Nathaniel Alcock.¹ Nathaniel Alcock became the second mayor of Kilkenny, Ireland. Benjamin had one sister, Deborah, and three brothers: John, Nathaniel, and Abraham. He studied anatomy at Trinity College in Dublin under James Macartney. He then apprenticed

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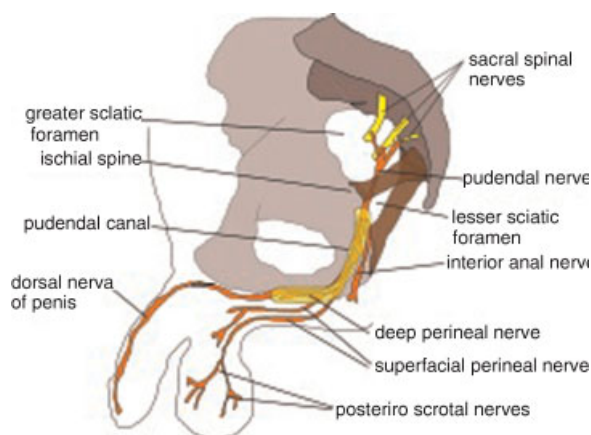


Figure 1 Illustration of the pudendal nerve anatomy. The pudendal nerve arises from the sacral plexus, passes through the greater sciatic foramen with the pudendal artery under the piriformis muscle, then over the sacrospinous ligament and under the sacrotuberous ligament, exiting the pelvis, to enter the lesser sciatic foramen. Then, still traveling with the pudendal artery, it goes through the pudendal canal, deep to the obturator internus fascia, emerging at the inferior pubic ramus, where it ascends deep to the ischiocavernosus to enter the dorsal surface of the penis or clitoris. Note that the artist depicts the pudendal canal, or Alcock's canal, as incorporating the entire posterior and part of the anterior portion of the third stage of the pudendal artery as described by Alcock, whereas the portion of the pudendal nerve that lies within the obturator fascia is just the posterior portion of the third stage, along the ischial ramus, and not along the pubic ramus. (Source: http://en.wikipedia.org/wiki/File:Pudendal_nerve.svg.)

with Dr. Abraham Colles, known for his descriptions of Colles' fascia and Colles' fracture. In 1827 Benjamin became a Member of the Royal College of Surgeons in Ireland. He taught anatomy at the Park Street School in Dublin before moving on to be the first Professor of Anatomy and Physiology at Queen's College in Cork in 1849. He was asked to resign in 1853 secondary to a dispute regarding of the workings of the Anatomy Act. He was not married. In 1859, he emigrated to the United States and no further record of him has been found.

Alcock's Description of a Canal

Benjamin Alcock described the canal that bears his name in the *Cyclopaedia of Anatomy and Physiology* (1836–1839), a six-volume text edited by Dr. Robert B. Todd. Although Alcock's canal is often referred to in pudendal *nerve* entrapment pathology, Dr. Alcock described the canal while writing about the course of the internal pudendal *artery*, mentioning briefly that the pudendal nerve accompanies the artery during its course, without giving a detailed description of the anatomy of

the nerve in relation to the canal.² In the chapter "Iliac Arteries," Alcock states that the course of the pudendal artery can be divided into three stages, starting from its origin at the internal iliac artery until it becomes the dorsal artery of the penis/clitoris. The first stage is the pudendal artery's course from its origin until it leaves the pelvis at the sacrospinous ligament. The second stage is the pudendal artery's course; it is shortest between the sacrospinous and the sacrotuberous ligament, when it is outside the pelvis. The third stage, he writes, is the "longest and most important portion of its anatomic course." During this stage, the artery "situates within the pelvis and lies along the inside of the tuberosity of the ischium and the rami of the ischium and pubis." As the posterior and anterior parts of its course are different, Dr. Alcock mentions them separately. He describes how the posterior course of the artery lies within a canal in the obturator fascia, which ends when the artery emerges from this canal at the origin of the "triangular ligament of the perineum" (now termed the "transverse perineal membrane").³ As the artery proceeds anteriorly, it becomes more superficial; it is enclosed in a sheath from this triangular ligament that attaches to the ramus of the pubis at the anterior border of the ischial tuberosity, and finally emerges from this triangular ligament, beneath the "subpubic ligament" (now termed the "transverse perineal ligament"),⁴ as the dorsal artery of the penis. The pudendal nerve is typically drawn with Alcock's canal surrounding both the anterior and posterior portions of the third stage of the pudendal artery course (Fig. 1).

Cadaveric Studies

From our dissections, we confirm that the pudendal nerve arises from the sacral spinal nerves (S2, S3, and S4) and travels anteriorly. The pudendal nerve travels between the sacrotuberous ligament, which is superficial to it, and the sacrospinous ligament, which is deep to it. Approximately 1 cm distal to these ligaments, the nerve enters a sheath formed by the fascia of the obturator internus muscle (the entrance of Alcock's canal, the beginning of the posterior portion of his third stage of the course of the pudendal nerve). It then travels distally (anteriorly) along with the pudendal artery and vein within this sheath, from posterior to anterior, medial to the obturator muscle, in the lateral side of the ischio-rectal fossa. At the anterior border of the ischial tuberosity, the junction with the inferior pubic ramus, the nerve exits from the obturator fascial sheath (exit of Alcock's canal, or beginning of the anterior portion of the third stage of the pudendal artery) and proceeds superiorly along the pubic ramus, to be enclosed within a sheath of the transverse perineal membrane and the attachment of the corpora cavernosa to the pubic ramus. As the pudendal nerve emerges from this sheath, which

Alcock did describe, the pudendal nerve crosses over the transverse perineal ligament to become the dorsal nerve of the clitoris or penis (Figs. 2 and 3).

The first branch of the pudendal nerve is the rectal nerve. In all five fixed cadavers, the rectal nerve was found to branch ~2 to 3 cm distally from the ischiotuberous ligament. In the fresh cadaver, however, the rectal nerve was found to branch between the sacrospinous and sacrotuberous ligament. The fascial extension at this point is curved and was described by Alcock to be its falciform part (“the great sacro-sciatic ligament and it’s [sic] falciform process”),² and this location may be the immediate cause of symptoms that involve just the perirectal area. This is not the pudendal canal that Alcock described, but rather lies outside and posterior to the pudendal canal. Distal to this, within the pudendal canal, the pudendal nerve branches into its two major terminal branches, with fibers destined to innervate the perineum (the perineal nerve) and either the clitoris or the penis (the dorsal nerve). At the exit of Alcock’s canal, at the anterior border of the pubic ramus, the perineal nerve branches to innervate the skin of the perineum scrotum/labia and does not continue into the anterior

portion of the third stage of the pudendal artery’s course. Distal to this exit from Alcock’s canal, the pudendal nerve turns cephalad, going along the inferior pubic ramus to reach the pubic symphysis, ending at the transverse perineal ligament (Fig. 4).

DISCUSSION

Based upon a critical reading of Alcock’s description of the anatomic course of the pudendal *artery*, it is possible to conclude that Alcock’s canal, relating to the pudendal *nerve*, is the region Alcock termed the posterior part of the third stage of the pudendal artery’s course. “Alcock’s canal” therefore should be used to describe that portion of the pudendal nerve within the obturator fascia overlying the obturator internus muscle. “Alcock’s canal,” by definition, therefore does not include the pudendal nerve within the true pelvis (i.e., prior to crossing the sacrospinous ligament), the region when the nerve is between the sacrospinous and sacrotuberous ligaments, and the region in which the rectal branch of the pudendal nerve crosses the curved falciform process connecting the sacrotuberous



Figure 2 Fixed male cadaver, dissection of left pudendal nerve. (A) Posterior view of the left buttock with the sciatic nerve (SN) emerging beneath the pyriformis muscle (PM), the ischial tuberosity (IT) seen after division of the sacrotuberous ligament (three black ink dots in Fig. B), the pudendal nerve entering the Alcock’s canal, a canal within a sheath of the fascia of the obturator internus muscle (O). The vessel loupes are on the pudendal nerve (*) and on the pudendal vein (**); the pudendal artery (***) was cut. (B) Medial view after hemi-section through the pelvis. Posterior to the left. Vessel loop is noted on pudendal nerve as it leaves the lesser sciatic notch, passing beneath the obturator internus fascia. (C) Same view as in (B) but now the fascia has been lifted up with forceps (F). Note the pudendal nerve (*) giving off the rectal branch (R) immediate distal to the divided sacrotuberous ligament, and then, just distal to this, dividing into its terminal perineal (P) and dorsal branch (D).

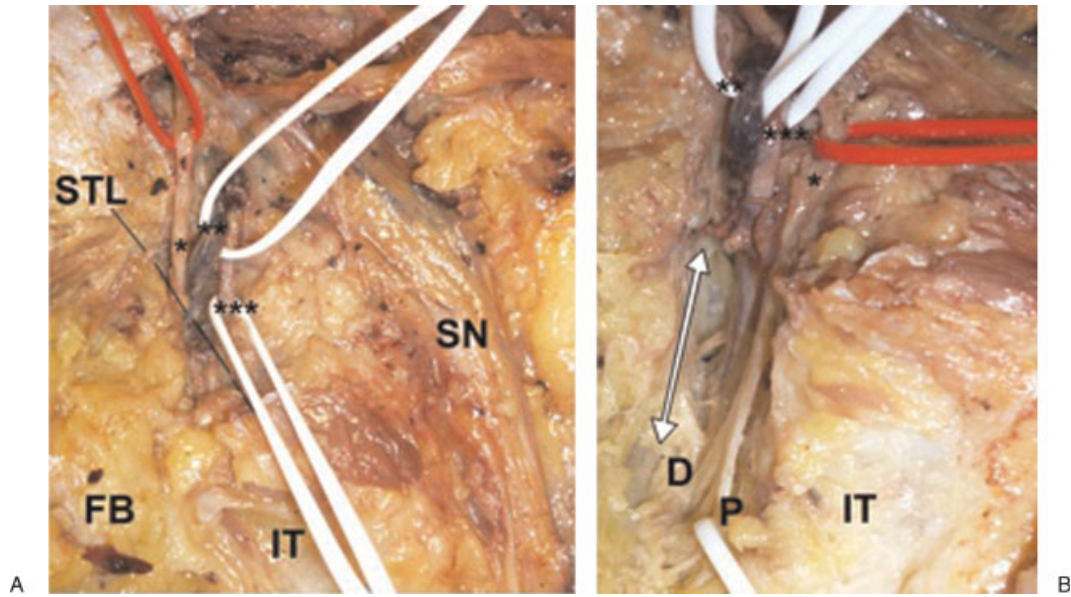


Figure 3 Fixed male cadaver, dissection of the right pudendal nerve (posterior view). (A) Note sciatic nerve (SN) and pudendal neurovascular bundle exiting the greater sciatic foramen (*pudendal nerve, **pudendal vein, ***pudendal artery). They are in close proximity and diverge at the ischial tuberosity (IT). The sacrotuberous ligament (STL) has been divided (dotted lines). Fat (FB) covers the pudendal nerve lying deeper within the obturator internus fascia. (B) Close-up of above view after removal of the fat and dissection of the pudendal nerve (*) from beneath the obturator external fascia to demonstrate the distal branches; perineal (P) and dorsal nerve to the penis (D). In this specimen, the rectal nerve came off more proximally and is not shown in this specimen. Ischial tuberosity (IT) borders the exposed Alcock's canal (double-headed arrow; **pudendal vein, ***pudendal artery).

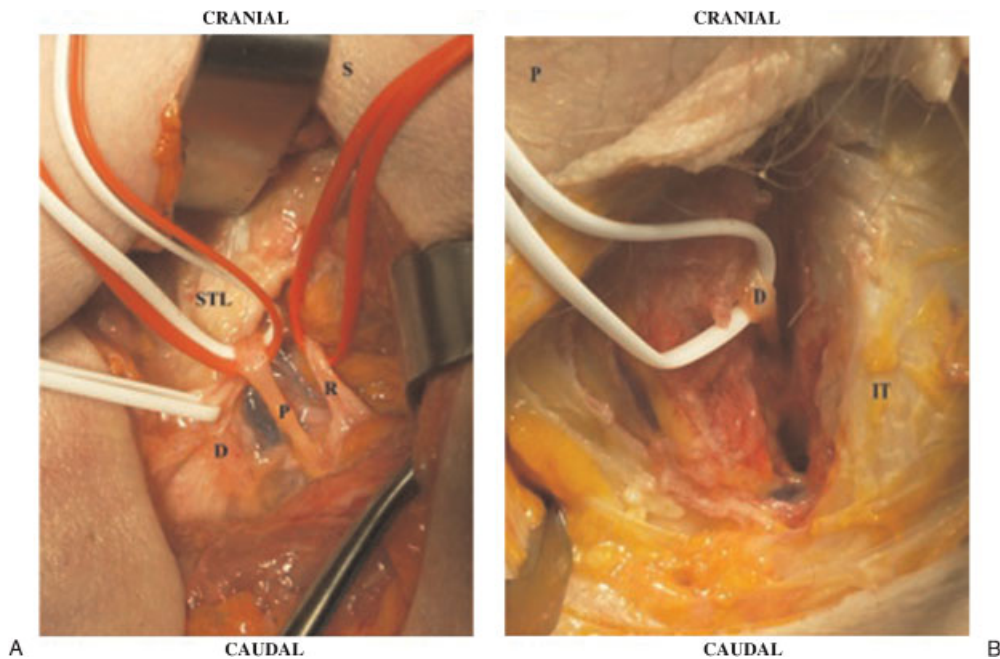


Figure 4 Fresh male cadaver. Dissection of right pudendal nerve. (A) Posterior surgical approach. Incision between sacrum (S) and ischial tuberosity. Branches of pudendal nerve: rectal nerve (R), perineal nerve (P), dorsal nerve to the penis (D). STL, sacrotuberous ligament. (B) Anterior surgical approach. Incision along the inferior pubic ramus. Dorsal nerve of the penis (D) is exposed as it exits the posterior portion of Alcock's canal to ascend along the pubic ramus to the dorsum of the penis. Posterior scrotal skin is noted (P). IT, ischial tuberosity.

ligament to the ischial tuberosity at the site of the obturator foramen. Finally, “Alcock’s canal,” by definition, therefore does not include the passage of the pudendal nerve along the ramus of the pubis toward the pubic symphysis. It is clear that descriptive phrases such as the “pudendal canal syndrome” are imprecise and cannot describe the exact anatomic location to which either medical or surgical treatment should be directed.^{5,6}

Anatomic structures responsible for pudendal nerve entrapment have been identified along the entire course of the pudendal nerve not limited to the Alcock canal.^{7–11} A cadaveric study by Ahtari et al in 2006 showed that the pudendal nerve passed into the Alcock’s canal without giving any branches and then divided into the inferior rectal nerve, the perineal nerve, and dorsal nerve of the clitoris inside Alcock’s canal in 9 of 10 cadavers.¹² In one case, the inferior rectal nerve arose from the fourth sacral root within the pelvis and pierced the sacrospinous ligament to penetrate the ischiorectal fossa without entering Alcock’s canal. A Thai cadaveric study¹³ showed that 15 of 73 investigated inferior rectal nerves originated independently from the S4 root and never joined the main pudendal nerve. Eight of these 15 inferior rectal nerves pierced through the sacrospinous ligament, perhaps making it prone for entrapment.¹³ In our study, five rectal nerves were found to branch ~2 to 3 cm distally from the ischiotuberous ligament; one rectal nerve was found to branch between the sacrospinous and ischiotuberous ligament. These anatomic studies clearly show that the rectal nerve is *not within* Alcock’s canal in the majority of cadavers, although in a clinical paper, Robert et al¹⁴ give a diagram of a rectal nerve branch coming through the obturator fascia.

Alcock is not the first to have his anatomic description of an artery become attributed later to a nerve entrapment. The ligament that Struthers described, related to the brachial artery, subsequently became misrepresented as a site for proximal ulnar nerve entrapment, which it is not.¹⁵

The present study places Alcock’s canal into historical perspective and provides the opportunity for future studies to derive an algorithm that relates the patient’s symptoms to the possible site or sites along the course of the pudendal nerve where surgical decompression may be beneficial.

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