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REVIEW ARTICLE

Is the pelviureteric junction an anatomical entity?

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Abstract *Objective:* The concept of the pelviureteric junction has existed for more than a century and yet there is no clear anatomical definition of this junction. This systematic review addresses the question of whether the human pelviureteric junction is a discrete anatomical entity.
Methods: A systematic literature review was undertaken to investigate the normal gross and microscopic anatomy of the pelviureteric junction using the electronic databases MEDLINE, PubMed, Cochrane Library and Google Scholar.
Results: In most individuals there is a gradual transition between the renal pelvis and ureter with no external features indicating the presence of a discrete pelviureteric 'junction'. Internally, however, luminal mucosal folds are prominent in this region. There is no consensus on the arrangement of muscle fibers at the pelviureteric junction (which may be age-dependent) although some studies suggest a focal thickening in the muscle wall consistent with physiological observations suggesting a high pressure zone capable of regulating urine flow. Studies of innervation have shown no evidence of specialization at this site.
Conclusions: There is some evidence that a pelviureteric *region* can be delineated anatomically and physiologically. However, although it may be a useful clinical concept, there is no sound anatomical basis for an actual pelviureteric *junction*.

Introduction

The concept of a ureteropelvic or pelviureteric junction (PUJ) is well established as a consequence of this region being a common site of urinary tract obstruction, especially in children [1], yet its anatomical basis is unclear. It is not recognized as a discrete entity in anatomical reference texts [2–4]. In the embryo, the region develops from the ureteric bud which also forms the adjacent pelvis and ureter, and so the PUJ does not represent a junction in any developmental sense [5]. Smooth muscle cells appear synchronously in the renal pelvis and ureter at about 12 weeks' gestation [6]. Unlike the ureter, which undergoes recanalization after passing through a solid phase during early human gestation

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[7], the PUJ region probably remains patent throughout development [8]. So, is there any evidence that the human PUJ is a discrete anatomical entity? We have attempted to answer this question by undertaking a systematic review of the literature documenting the structure of the *normal* human PUJ. The aim of the review is not to analyze the multiple theories concerning the pathogenesis of PUJ obstruction, which broadly fall into structural (intrinsic or extrinsic obstruction) and functional disorders (abnormal smooth muscle function or impaired motility secondary to a deficiency of interstitial cells of Cajal), but instead to focus on the anatomy of the pelviureteric region to critically examine whether the concept of a pelviureteric *junction* is justified.

Search methods

The electronic databases MEDLINE, PubMed, Cochrane Library and Google Scholar (first 10 pages) were searched for relevant English language articles. Search terms comprised "pelviureteral junction" or "ureteropelvic junction" or "pelviureteric junction" or "pelviureteral junction" AND "anatomy" OR "vascular" OR "histology" OR "endoscopy". "Ureter" AND "anatomy" was searched separately. Papers containing original data were selected and relevant secondary references retrieved from bibliographies. The emphasis was on human studies because of functional differences in pyeloureteral activity between multicalyceal systems (human, pig) and unicalyceal systems (guinea pig, rabbit), and structural species differences in the arrangement of smooth muscle at the pelviureteric region [9]. The following represents a summary of the findings of this systematic review of the normal anatomy of the human pelviureteric region.

Gross anatomy

In a study of 200 normal urograms, Jewett (1940) concluded that 14% had a region of discrete narrowing consistent with a PUJ [10]. In the majority of cases, the pelviureteric region was funnel-shaped with no discernible distinction between the renal pelvis and ureter. In a similar study of 500 supine pyelograms, Hanley (1959) found that approximately 90% of cases had a smooth funnel-shaped renal pelvis which merged imperceptibly with the ureter, but in the remainder the renal pelvis was rounded with a clearly definable PUJ [11].

Cadaver studies have yielded conflicting results. Cussen (1967) studied the post-mortem dimensions of 276 ureters from fetuses, infants and children who had no evidence of urinary tract pathology [12]. Defining the PUJ loosely as 'the narrow site of transition from the larger caliber of the renal pelvis to the smaller caliber of the ureter', he considered that this transition was usually 'abrupt and obvious' but acknowledged that in some specimens it was more gradual. Using a series of probes he determined that the internal diameter of the PUJ was the second narrowest point in the ureter after the ureterovesical junction. In a study of 41 PUJs from adults and children, Foote et al. (1970) were unable to identify the PUJ as a discrete site because of the smooth transition from pelvis to ureter [13]. In a smaller study, Shafik and Al-Sherif (1999) defined the PUJ as the 'narrowest lower end of the renal pelvis at its junction with the ureter' and concurred that it had no definable external features [14].

A gradual tapering of the renal pelvis into the ureter rather than a discrete transition is also evident on endoureteral sonography [15]. Thus, in the vast majority of cases, there are no external features that clearly define a pelviureteric 'junction'.

According to some authors, the PUJ region can be identified from its internal mucosal appearance. Murakumo et al. (1997) noted mucosal folds within seven non-obstructed PUJs removed from patients undergoing nephrectomy for transplant or tumor [16]. In a more systematic study of 25 cadavers, Shafik and Al-Sherif (1999) characterized the PUJ as a region containing 'crowded mucosal folds' forming an internal rosette [14]. Folds were smaller and fewer in the adjacent pelvis and ureter. Using this definition, they estimated the mean length of the PUJ as 6.2 ± 1.4 mm (range 5–9 mm). This correlated with a high pressure zone recorded in healthy volunteers (see below).

Muscle wall

As with other parts of the ureter, the wall of the pelviureteric region is composed of three layers: an outer adventitia, a smooth muscle layer interspersed with collagen bundles [16], and an inner mucosal layer consisting of urothelium overlying a lamina propria. The orientation of muscle fibers is controversial.

From an analysis of PUJs obtained at autopsy from adults and children, Foote et al. (1970) reported a combination of circular, longitudinal and oblique muscle fibers at the PUJ [13]. They noted a gradual transition from a preponderance of circular muscle in the pelvis to a preponderance of longitudinal muscle in the upper ureter. Hanna et al. (1976) studied 28 normal ureters mostly from autopsies and commented that whilst the ureter had an inner longitudinal and outer circular muscle layer, the muscle layer of the PUJ was ill-defined [17]. Kench (1982) studied PUJs from 23 adult cadavers with no known urinary tract pathology and reported no difference in the basic arrangement of muscle between the pelvis and ureter, which was arranged in two poorly defined layers of variable thickness, an inner longitudinal spiral layer and an outer circular layer [18]. Murakumo et al. (1997) similarly reported a muscle coat organized into two layers but did not elaborate on the orientation of these layers [16].

In an elegant and detailed study of 12 autopsy specimens ranging in age from 1 month to adulthood, Kaneto et al. (1991) examined the three-dimensional arrangement of smooth muscle bundles at the PUJ (defined as the site where the uppermost ureter joins the funnel-shaped pelvis) [19]. These authors documented age-related changes in the orientation of muscle fibers. Circular muscle fibers predominated in infants. After 2 years of age, oblique muscle bundles were evident becoming progressively more dominant with increasing age. A thin inner longitudinal muscle layer was identified from 2 years of age. They concluded that the adult pattern of muscle bundles at the PUJ is dominantly one of an oblique mesh with a thin inner layer