Abstract

OBJECTIVE—To examine the published literature and suggest a resolution to the confusion that exists in levator ani muscle descriptions and terminology.

DATA SOURCES—A MEDLINE search was performed using the keyword “levator ani,” limited to human studies in women. References found in these articles were reviewed to identify research reported before 1966 and articles not included in the search.

STUDY SELECTION—Studies were accepted if they contained direct observations of female specimens. Only those that contained specific descriptions or illustrations of the muscle origins and insertions in more than 5 female specimens were included. Review of 265 human studies yielded 9 qualifying articles, and reference tracing disclosed 3 additional reports.

TABULATION, INTEGRATION, AND RESULTS—The literature review identified 5 origin-insertion pairs consistently described in studies directly examining the levator ani muscle in women, but 16 terms were used by authors for these 5 components of the muscle. Labeled illustrations often provided more precise information than was provided in the text. Terms were reviewed for inconsistencies of usage and appropriateness of term choice. The terms puboperineal, pubovaginal, and puboanal (for components of the pubovisceral ["pubococcygeal"] muscle), along with puborectal and iliococcygeal, are sufficient to describe the divisions of the levator ani muscle.

CONCLUSION—Although there was great diversity and conflict in terms chosen among the original articles, the number of origin and insertion pairs was relatively consistent among authors and confusion can be avoided by standardizing terminology.

LEVEL OF EVIDENCE: III

There is no considerable muscle in the body whose form and function are more difficult to understand than those of the levator ani, and about which such nebulous impressions prevail.”1 Despite a century of medical progress since Dickinson offered this observation, the details of levator ani muscle anatomy remain poorly understood.

Research demonstrates that the levator ani muscle is critically important to pelvic organ support2,3. Magnetic resonance imaging has made muscle details vividly visible.4 Its damage in women with pelvic floor dysfunction has been documented,5 and the origin of this damage during vaginal birth has been described.6 There are several muscle damage patterns observed after vaginal birth6 and a variety of symptoms that can be associated with these different appearances. Discovering the relationship between the component that is damaged (eg, pubovaginalis versus puborectalis) and the symptoms a patient experiences (eg, stress incontinence versus rectocele) will depend on understanding the specific function of each
muscle component. This, in turn, depends on knowing the precise origins and insertions of each part of this complex muscle.

While building a 3D computer model of the levator ani muscle, we performed a review of the literature to determine the anatomy of the different subdivisions of the levator ani muscle. These studies contain 16 different overlapping terms for different parts of the muscle (see box). The terminology in these reports was so confusing and inconsistent that each additional article read added confusion rather than clarity to the picture of levator ani anatomy. This problem was so intractable that despite careful study over many hours, it seemed impossible to reconcile one author’s findings with another. However, once the origin-insertion pairs for each part of the muscle were studied separately from the terms applied to them, the actual anatomy was found to be very consistent among the different studies. The purpose of this report is to review the established literature and discern consistency of origin-insertion pairs and to clarify descriptions and terminology.

**SOURCES**

We reviewed the medical and anatomical literature by performing a MEDLINE search using the keyword “levator ani,” limiting the request to human studies and female gender. Articles not included in our search and older literature were sought by pulling references cited in the identified articles that might yield additional original observations to identify articles not included in the search as well as publications before 1966.

### Sixteen Terms Found in the Literature for Portions of the Levator Ani Muscles

- Combined longitudinal muscle layer of the rectum
- Middle fibers of anterior layer
- Pelvic fibers of anterior layer
- Pelvic layer
- Perineal fibers of anterior layer
- Posterior fibers
- Puboanalis
- Puboanalis sling
- Puboanal sphincteric sling
- Pubococcygeus
- Puboperineus
- Puborectalis
- Puborectoanalis
- Pubourethralis
- Pubovaginalis
- Superficial perineal layer of anterior fibers
STUDY SELECTION

We selected articles that reported original observations from investigators who had personally examined the levator ani muscle, that contained specific descriptions of the origins and insertions of the muscle components in women, and that included more than 5 female specimens.

The MEDLINE search initially identified 265 human studies containing the keyword “levator ani,” 198 of which concerned women. Of these, 9 were anatomical articles where the author reported on direct observations of the muscle. Reference tracing identified 6 additional articles cited in these studies that were not identified in the original search. In total, 12 articles were screened, and in 9 the origin and insertion of each portion of the levator ani was sufficiently described to permit inclusion. Articles with a general description of the muscle but without precise origins and insertions could not be analyzed and were excluded. One article contained a word-for-word translation of Holl’s research in sufficient detail to permit inclusion of this older article. The number, state of specimen, preparation criteria for selection, age range, gender, dissection approach, and use of histology were recorded as reported by each author (Table 1). Each article was analyzed for the author’s description of origin-insertion pairs. This included analysis of labeled illustrations that often provided more precise information than was included in the text. The terms chosen by each author for each origin-insertion pair were recorded.

RESULTS

There was consensus among authors on the iliococcygeus muscle seen to arise from the arcus tendineus levatoris ani and insert in the iliococcygeal (“anococcygeal”) raphe. Therefore, our review is concerned with those portions of the muscle that arise from the pubic bone, the “pubococcygeus and puborectalis” portions of the levator ani.

The findings of our review are presented in Table 2. Because all of these components originate from the pubic bones, the table is organized by insertion. The names that the authors assigned to origin-insertion pairs are listed in this table. Table 2 demonstrates that the majority of authors describe the same origin-insertion pairs. However, different names are used for the same origin-insertion pairs by different authors. As an example, the portion of the levator ani that originates from the pubic bone and inserts into the intersphincteric groove (the plane between the external and internal anal sphincters) are called the puboanalis by Lawson, the puborectalis by Holl and Courtney, and the pubococcygeus by Curtis and Shafik. Roberts describes this same origin-insertion pair as making up part of both the pubococcygeus and the puborectalis portions.

Furthermore, authors do not agree on the presence of certain origin-insertion pairs as also highlighted by Table 2. This may be the result of the historical preponderance of reporting on male anatomy. Curtis and Roberts name the fibers that originate from the pubic bone and insert into the vaginal wall as the pubococcygeus, whereas they are called the puborectalis by Smith. Smith, however, describes a similar adjacent relationship but states that the fibers do not insert into the wall of vagina. Ayoub and Bustami also describe this origin insertion pair but assign different names; pelvic fibers of anterior layer and superficial perineal layer of anterior fibers.

All authors except Curtis et al describe a muscle (puborectalis) arising from the pubis on either side and inserting into the fibers of the opposite side to form a sling behind the rectum. Again the nomenclature assigned to this sling differs widely.
Table 3 summarizes the system used by Terminologia Anatomica, the successor to Nomina Anatomica. Terminologia Anatomica divides the pubococcygeus into the puboperinealis, pubovaginalis (in the female), and puboanalis. This division adequately reflects the origins and insertions found in our review (Fig. 1 and Fig. 2).

CONCLUSION

Clarifying this anatomy and its terminology is especially important. There is a rapidly growing body of research concerning the levator ani muscle and pelvic floor dysfunction and this muscle is a critical component of the pelvic organ support system. Recent magnetic resonance imaging research has displayed defects in this muscle in women with pelvic floor dysfunction that arise during vaginal delivery. Each origin-insertion pair has a unique mechanical function and knowing which portion of the muscle is damaged will be needed to understand how this injury might result in a specific type of pelvic organ prolapse or pelvic floor dysfunction. For example, the pubovaginalis is that portion of the levator ani muscle that is attached to the urethral supports. If this part were to be injured, it might affect urethral support, but not fecal continence whereas injury to the puborectalis muscle might have the opposite effect. Therefore, correctly identifying each element of the muscle will prove to be important in determining the effect of injuries to specific parts of the muscle.

The confusing terminology used to describe the levator ani muscle in the literature obscures the consistent agreement concerning the origin and insertion of individual muscle components. We have identified the relatively constant pattern of the muscle described by various authors and established consensus concerning origins and insertions. Although not perfectly consistent, consensus concerning the origins and insertions of the muscle was evident. The nomenclature reported by Lawson most closely approaches the standard practice of naming a muscle based on its origin and insertion. This captures the mechanical actions that a muscle could effect. There are, however, some minor problems with this construction. For example, the term pubourethralis is used when, in fact, there is not a connection between these structures in the female. In addition, replacement of puborectalis by the term puboanalis sling is likely to cause confusion with the term puboanalis (a good term for the fibers inserting in the anus in the intersphincteric groove) when the older term puborectalis for those fibers that pass behind the anorectal junction can be retained. This approach, which seeks to achieve the standard anatomical practice of naming a muscle by its origin-insertion pair, is worth using.

The problems that arise because of misleading names can be real. The term pubococcygeus muscle incorrectly implies a connection between the pubis and coccyx and implies that this muscle’s function was to move the coccyx, when, in fact, most of the muscle inserts into the walls of the vagina and anorectum to elevate these structures and close the genital hiatus. We would favor abandoning the term pubococcygeus and replacing it with Lawson’s term, pubovisceral muscle.

It is possible to properly describe the origins and insertions even if the name is misleading as several authors have done, but the problems that persist in remembering insertions that are different from the structure’s name are real. The obvious and long-standing concern about changing terms too frequently must be balanced by the errors that result from generations of medical students learning a misleading name that will imply incorrect anatomy and function.

Several conceptual, anatomical, and technical factors contribute to problems with levator ani muscle descriptions. All authors performed dissections personally. However there is a diverse range in detail provided by authors as to the methods of dissection used. Some authors, such as Bustami and Ayoub, give more detailed descriptions and specify excluding cadavers with known anomalies, pathology, or prior pelvic surgery, whereas others have general...
discussions. In addition, the muscle atrophy found in anatomy laboratory specimens and
distorting methods of cadaver preservation are known to alter or impede accurate description
and cause distortion. Only Smith mentions parity as a factor that might influence the
anatomy, and none of the authors considered only dissecting nulliparous cadavers to avoid
studying muscles that had been altered during birth. Moreover, many authors carried out the
majority of their anatomical dissections on male cadavers and then either described the female
as a variant or not at all (even although they have dissected female cadavers). Accurate
understanding is also hampered because the cadavers dissected are mainly parous and some
contain birth-induced injuries to the muscle that lead to variations in description.

Injuries to the levator ani muscle during childbirth play a role in the development of urinary
incontinence and pelvic organ prolapse. Current terminology is inadequate for
understanding the function of this muscle. It is only by understanding the components of the
levator ani that we can appreciate how damage to this muscle results in pelvic floor dysfunction.
The function of a muscle can best be understood by knowing what it is attached to. Therefore,
this review focuses on analyzing the origin-insertion pairs described in studies to gain a better
appreciation of the action of this muscle. The origin-insertion pairs are described consistently
among authors and quickly become understandable, and the nomenclature assigned to each
pair reflects muscle attachments.

References


Fig. 1.
Schematic view of the levator ani muscles from below after the vulvar structures and perineal membrane have been removed showing the arcus tendineus levator ani (ATLA); external anal sphincter (EAS); puboanal muscle (PAM); perineal body (PB) uniting the 2 ends of the puboperineal muscle (PPM); iliococcygeal muscle (ICM); puborectal muscle (PRM). Note that the urethra and vagina have been transected just above the hymenal ring. Copyright © DeLancey 2003.
Fig. 2.
The levator ani muscle seen from above looking over the sacral promontory (SAC) showing the pubovaginal muscle (PVM). The urethra, vagina, and rectum have been transected just above the pelvic floor. PAM = puboanal muscle; ATLA = arcus tendineus levator ani; and ICM = iliococcygeal muscle. (The internal obturator muscles have been removed to clarify levator muscle origins.) Copyright © DeLancey 2003.
## Table 1

### Comparison of Nine Anatomical Articles

<table>
<thead>
<tr>
<th>Author</th>
<th>Description of cadavers</th>
<th>Male</th>
<th>Female</th>
<th>Age range</th>
<th>Dissected by author</th>
<th>Observed by author</th>
<th>Histology</th>
<th>Dissection approach</th>
<th>Exclusion criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smith 1923</td>
<td>&quot;Many&quot;</td>
<td>Yes</td>
<td>Yes</td>
<td>6</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Unspecified</td>
<td></td>
</tr>
<tr>
<td>Curtis et al 1939</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>Unspecified</td>
<td></td>
</tr>
<tr>
<td>Courtney 1950</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>...</td>
<td>...</td>
<td>Yes</td>
<td>40</td>
<td>Perineal and pelvic</td>
<td></td>
</tr>
<tr>
<td>Wilson 1967, 1973</td>
<td>4 Embryos, 27 fetuses, 6 infants, 50 adults</td>
<td>4</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>Yes</td>
<td>79</td>
<td>Yes</td>
<td>Unspecified</td>
</tr>
<tr>
<td>Lawson 1974, 1971</td>
<td>13 Neonates and infants</td>
<td>Yes</td>
<td>Yes</td>
<td>1 d–62 y</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Unspecified</td>
<td></td>
</tr>
<tr>
<td>Shafik 1972, 1975</td>
<td>22 postmortem (7 infants)</td>
<td>15</td>
<td>7</td>
<td>17–66 y</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Anomalies, pathology, prior pelvic surgery</td>
<td></td>
</tr>
<tr>
<td>Ayoub 1979, 1981</td>
<td>15 Embalmed, 11 postmortem subjects</td>
<td>16</td>
<td>10</td>
<td>17–66 y</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Pelvic</td>
<td></td>
</tr>
<tr>
<td>Roberts et al 1987</td>
<td>50 Embalmed, 4 unembalmed</td>
<td>26</td>
<td>28</td>
<td>...</td>
<td>Yes</td>
<td>...</td>
<td>No</td>
<td>Perineal</td>
<td></td>
</tr>
<tr>
<td>Bustami 1988</td>
<td>16 Embalmed adults, 8 postmortem subjects</td>
<td>14</td>
<td>10</td>
<td>20–70 y</td>
<td>Yes</td>
<td>...</td>
<td>No</td>
<td>Anomalies, pathology, prior pelvic surgery</td>
<td></td>
</tr>
</tbody>
</table>
### Table 2

Insertions of the Fibers Arising From the Pubic Bones

<table>
<thead>
<tr>
<th>Author</th>
<th>Insertion</th>
<th>Insertion</th>
<th>Sling</th>
<th>Deep external anal sphincter</th>
<th>Coecyx</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holl 1897</td>
<td>Vagina (urethra)</td>
<td>Pubococygeus</td>
<td>Puborectalis</td>
<td>Pubococygeus</td>
<td>Pubococygeus</td>
</tr>
<tr>
<td>Thompson 1900</td>
<td>. . .</td>
<td>Pubococygeus</td>
<td>. . .</td>
<td>Pubococygeus</td>
<td>. . .</td>
</tr>
<tr>
<td>Smith 1923</td>
<td>. . .</td>
<td>Pubococygeus</td>
<td>. . .</td>
<td>Pubococygeus</td>
<td>Pubococygeus</td>
</tr>
<tr>
<td>Curtis et al 1938</td>
<td>Pubococygeus (puboocytes)</td>
<td>. . .</td>
<td>Puborectalis</td>
<td>Pubococygeus, puborectalis</td>
<td>Pubococygeus</td>
</tr>
<tr>
<td>Courtney 1950</td>
<td>Puborectalis</td>
<td>Combined longitudinal muscle layer of the rectum, puborectalis</td>
<td>Combined longitudinal muscle layer of the rectum, puborectalis</td>
<td>Puborectalis, puborectalis</td>
<td>Pubococygeus</td>
</tr>
<tr>
<td>Lawson 1974</td>
<td>Pubovaginalis (pubourethralis)</td>
<td>Puboanalis</td>
<td>Puborectalis</td>
<td>Puborectalis</td>
<td>Pubococygeus</td>
</tr>
<tr>
<td>Shafik 1975</td>
<td>Pelvic fibers of anterior layer</td>
<td>Middle fibers of anterior layer</td>
<td>. . .</td>
<td>Pelvic fibers of anterior layer</td>
<td>Pelvic layer</td>
</tr>
<tr>
<td>Ayoub 1979</td>
<td>Pelvic fibers of anterior layer</td>
<td>. . .</td>
<td>. . .</td>
<td>Middle fibers of anterior layer</td>
<td>. . .</td>
</tr>
<tr>
<td>Bustami 1988</td>
<td>Superficial perineal layer of anterior fibers</td>
<td>Superficial perineal layer of anterior fibers</td>
<td>. . .</td>
<td>. . .</td>
<td>. . .</td>
</tr>
</tbody>
</table>
## Table 3
Terms and Descriptions Used in Terminologia Anatomica

<table>
<thead>
<tr>
<th>Terminologia Anatomica</th>
<th>Origin/Insertion</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Pubococcygeus&quot; (recommend pubovisceral)</td>
<td>Pubis/perineal body</td>
<td>Tonic activity pulls perineal body ventrally toward pubis</td>
</tr>
<tr>
<td>Puboperinealis</td>
<td>Pubis/vaginal wall at the level of the mid-urethra</td>
<td>Elevates vagina in region of the mid-urethra</td>
</tr>
<tr>
<td>Pubovaginalis</td>
<td>Pubis/intersphincteric groove between internal and external anal sphincter to end in the anal skin</td>
<td>Inserts into the inter-sphincteric groove to elevate the anus and its attached anoderm</td>
</tr>
<tr>
<td>Puboanalisis</td>
<td>Pubis/forms sling behind the rectum</td>
<td>Forms a sling behind the rectum forming the anorectal angle and closing the pelvic floor</td>
</tr>
<tr>
<td>Puborectalis</td>
<td>Tendinous arch of the levator ani/the 2 sides fuse in the iliooccygeal raphe</td>
<td>The 2 sides form a supportive diaphragm that spans the pelvic canal</td>
</tr>
</tbody>
</table>

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