

# Sternalis

## *An anatomic variant of chest wall musculature*

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### ABSTRACT

**Objectives:** To study the prevalence of sternalis muscle in the Kingdom of Saudi Arabia (KSA) and resolve the question of its genesis by studying the innervation of this uncommon variant of anterior chest wall musculature.

**Methods:** A morphological study of 75 adult cadavers of both sexes was carried out over a 5-year period by macroscopic dissection. We also retrospectively studied the medical records of 1580 adult females who had undergone screening and diagnostic mammographic imaging at King Khalid University Hospital, Riyadh, KSA, from 1997 to 2001.

**Results:** Out of 75 cadavers studied, 3 cases of sternalis muscle were observed. Two adult male cadavers had well developed bilateral sternalis muscles whereas one female cadaver exhibited right sided unilateral sternalis. All 5 sternalis muscles were positioned vertically, in a

parasternal position superficial to the medial part of pectoralis major and innervated by branches of intercostal nerves. None of the 1580 women, however, who had undergone mammographic imaging were found to be sternalis positive.

**Conclusion:** Consistent with other geographic populations of the world, the frequency of sternalis in KSA is approximately 4%; however, its innervation by the intercostal nerves, as observed in our study is not common. This study highlights the need for familiarity with sternalis, which may mimic a focal density in medial breast craniocaudal mammograms and may be encountered during reconstructive surgery of breast and chest wall.

Neurosciences 2002; Vol. 7 (4): 248-255

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The sternalis muscle, an uncommon anatomic variant of chest wall musculature with uncertain teleology and function, has been termed variously as Episternalis, Presternalis, Rectus Thoracis, Rectus Sterni and Superficial rectus abdominis.<sup>1-5</sup> The first description of sternalis dates back to the 17th century<sup>6</sup> when Cabrolus (1604) characterized this variant muscle in humans.<sup>7</sup> Since then the existence of sternalis has been reported in almost all continents throughout the world except the Arab peninsula.<sup>6,8-18</sup>

The incidence of the sternalis varies widely between nationalities, with a maximum frequency of 23.5% reported in the Chinese population<sup>19</sup> and a minimum (1%) prevalence in Taiwanese.<sup>20</sup> Some authors have reported an overall incidence of 3-5% for sternalis.<sup>18,21-25</sup> The sternalis muscle is present in approximately 8% of North American males and females and it is twice as often unilateral as bilateral.<sup>21</sup> Nevertheless this muscle is often unknown in clinical practice<sup>4,26-27</sup> and is not

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mentioned in most textbooks of anatomy. The sternalis muscle is usually a long, thin, flat muscle, arising from the infraclavicular part of the anterior chest wall, running longitudinally superficial to the medial part of pectoralis major in a paramedian position. It frequently extends up to the caudal end of the sternum to insert on the costal cartilages, sternum, pectoral fascia or the aponeurosis of the external oblique within the anterior layer of the rectus sheath.<sup>28</sup> The longitudinal parasternal location of the sternalis muscle suggests that it represents an aberrant extension of the rectus abdominis muscle; however, it is always superficial to the rectus abdominis and not continuous with it.<sup>4,21</sup> It is occasionally observed as an irregular focal density in the medial aspect of craniocaudal mammograms and may provoke serious difficulty in mammographic interpretations.<sup>29-30</sup> Improved mammographic positioning and the application of computerized tomography (CT) and magnetic resonance imaging (MRI), however, can establish the presence of this uncommon variant muscle with certainty.<sup>26</sup> After an extensive review of world literature, Jelev et al<sup>18</sup> classified the sternalis muscle into 2 types; unilateral and bilateral with 4 subtypes for each group (Figure 1). Moreover, they imposed certain criteria for designating any variant of the anterior chest wall musculature as sternalis. Although, the functional significance of this muscle is unknown, knowledge of this variant is imperative for Anatomists, Radiologists and Surgeons for the correct interpretation of mammograms and in reconstruction surgery. The prevalence of sternalis muscle has been studied in all continents of the world except in the Arab peninsula, and this is the first study carried out to evaluate its incidence in the Kingdom of Saudi Arabia (KSA).

**Methods. Gross morphologic study of cadavers.** Seventy-five formalin-fixed adult cadavers randomly assigned to medical students in the Anatomy Laboratory of the College of Medicine, King Saud University, Riyadh, KSA, for dissection were studied over a 5 year period. The pectoral skin, superficial fascia, the intercostal nerves and their anterior cutaneous branches were carefully dissected. In addition to the presence of any variant muscle in the parasternal part of the anterior chest wall, the anterior thoracic nerves and their possible communication with intercostal nerves were meticulously observed. Innervation and arterial supply of sternalis, when present, were traced carefully. The origin, insertion and attachment of the sternalis to the pectoral fascia, pectoralis major and rectus abdominis was documented, and its length and width were measured with a sliding vernier caliper.

**Review of medical records.** The radiologic records of 1580 women who had undergone screening and diagnostic mammographic imaging at

King Khalid University Hospital (KKUH), Riyadh, KSA between 1997 and 2001 were reviewed for any focal density in the medial aspect of the breast. The average age of the patients at the time of radiologic examination was 48.5 years. In equivocal cases, the CT and MRI were evaluated as well.

**Results.** Three cases of sternalis muscle among 75 formalin-fixed adult cadavers of both sexes, were observed over a 5 year period. One female cadaver had a unilateral sternalis, whereas 2 male cadavers presented with well-defined bilateral sternalis muscles. However, none of the 1580 women who had undergone breast imaging at KKUH, demonstrated on craniocaudal mammograms any unusual, irregular structure (flame-shaped focal density with ill-defined margins), that might represent the sternalis.

**Illustrative case one.** Two well-defined asymmetric bilateral sternalis muscles were found in a 55-year-old white male cadaver (Figure 2a & 2b). Both sternalis muscles were thin and flat, and located on the anterior chest wall deep to the skin and subcutaneous tissue in a paramedian position. The left sternalis was, in-fact, a double muscle, having a smaller lateral and a larger medial part. The larger medial part was 13 cm long and 2.5 cm wide at its widest point. Both components of the left sternalis shared a common origin from the left anterior surface of the manubrium and sternal tendon of the left sternocleidomastoid, and followed a vertical course inferiorly to a common insertion on the 5th and 6th costal cartilages and the aponeurosis of the external oblique muscle forming the anterior layer of rectus sheath. Both components of the left sternalis muscle were lying freely superficial to the pectoral fascia and the left pectoralis major and rectus abdominis muscles. They were supplied by branches of the internal thoracic artery and the 2nd, 3rd and 4th intercostal nerves. No branches of the pectoral nerves were found to innervate the sternalis.

The right sternalis was comparatively much shorter than the left counterpart (Figure 2a). It was 8 cm long and one cm in width at its maximum dimension. It had no continuity with sternocleidomastoid tendon. It occupied an infraclavicular position, extending from the right margin of sternal angle to the costochondral junction of the 5th rib. Like the left sternalis, it was positioned superficially to the pectoralis major muscle and fascia received its innervation from intercostal nerves and was irrigated by perforating branches of the right internal thoracic artery. The pectoralis major muscles were normal.

**Illustrative case 2.** A unilateral right sternalis muscle was observed in a 45-year-old white female cadaver (Figure 3). Its fibers were oriented at a right angle to those of the medial part of the pectoralis

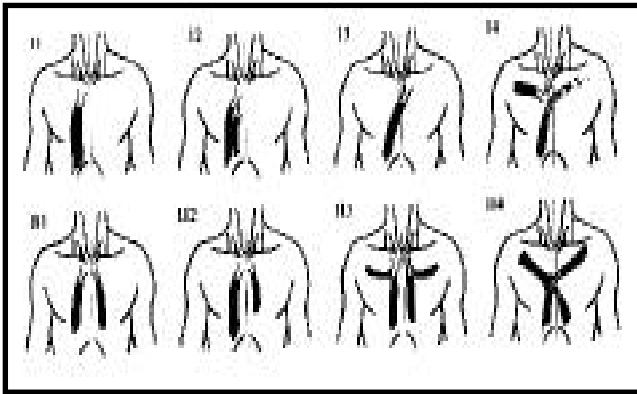


Figure 1 - Classification of sternalis muscles based on a review of the world literature.

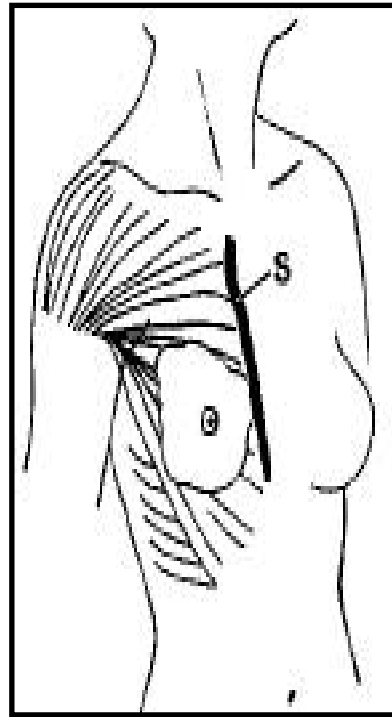


Figure 3 - Schematic drawing of a unilateral right sternalis. S - sternalis muscle.

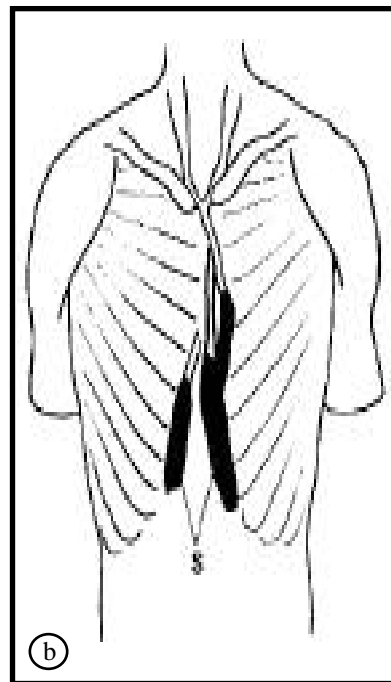
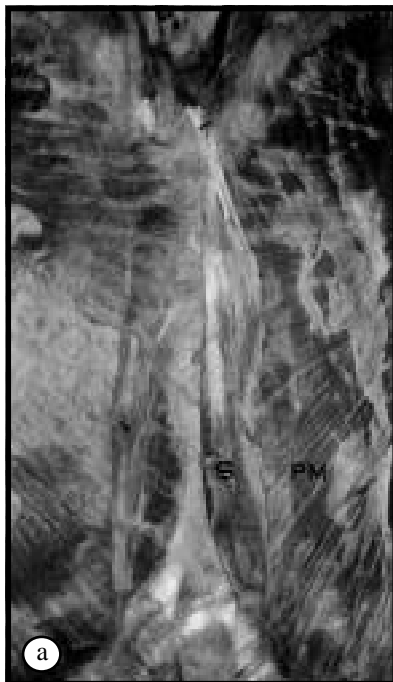
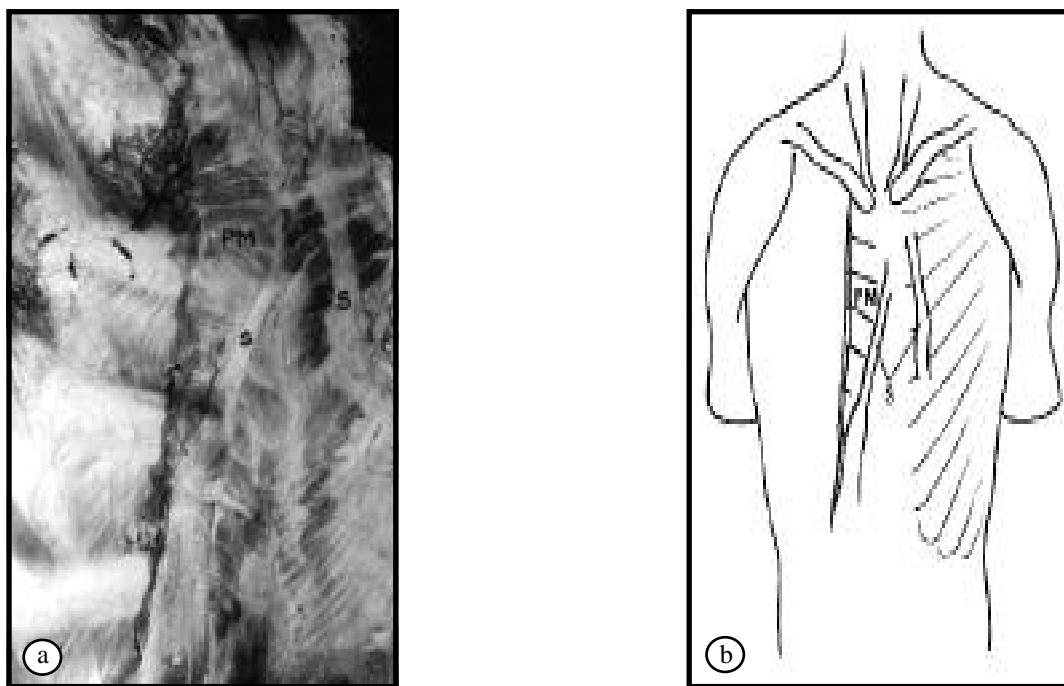


Figure 2 - Photograph of illustrative case one showing the a) bilateral sternalis muscle and b) the schematic drawing of Figure 2a. S - sternalis muscle, PM - pectoralis major.



**Figure 4** - Photograph of illustrative case 3 showing the a) bilateral sternalis muscle and b) the schematic drawing of Figure 4a. S - sternalis muscle, PM - pectoralis major.

major muscle. The sternalis was clearly separated from the pectoralis major by fat and extended from the right margin of the manubrium (being continuous with tendons of both sternocleidomastoid muscles through tendinous fibers) to the right 4th and 5th costal cartilages. It was 11 cm long and 1.4 cm wide at its maximum dimension and was innervated by anterior cutaneous branches of the right 3rd and 4th intercostal nerves.

**Illustrative case 3.** During routine dissection of a 52-year-old white male cadaver, a pair of asymmetric sternalis muscles were observed. The right sternalis was attached to the sternal angle by a 7 mm wide flat tendon. For its initial 4 cm it was positioned obliquely and then assumed a vertical parasternal course anterior to the medial part of the right pectoralis major muscle. It was inserted through fleshy fibers to the right 5th costal cartilage and the aponeurosis of the external oblique muscle (**Figures 4a & 4b**). It was 12 cm long and 2.3 cm wide on its maximum width, just above the insertion site. The left sternalis was ill-defined, consisting of a mixture of aponeurotic and fleshy fibers extending vertically from the sternal tendon of the left sternocleidomastoid to the level of the left 3rd intercostal space where it merged with the pectoral

fascia. Both sternalis muscles were innervated by intercostal nerves.

**Discussion.** Although the sternalis muscle has been investigated widely (**Table 1**)<sup>31</sup> since the first description of its morphology by Cabrolius and innervation by Hallett,<sup>6,7</sup> its embryological origin remains a mystery. Different authors, on the basis of morphology and innervation, have assumed sternalis to be derived from different neighboring muscles, such as pectoralis major,<sup>11,25,28,52,59,60</sup> rectus abdominis,<sup>3,61</sup> sternocleidomastoid,<sup>3,23</sup> and the panniculus carnosus.<sup>6,15,21</sup> From a morphologic viewpoint, the innervation of such muscles should correspond to that of the sternalis muscle. With an emphasis on innervation, the debate of the origin has now converged into 2 sources: a) sternalis is either derived from pectoralis major with innervation from the pectoral nerves or b) rectus abdominis derived, with innervation by intercostal nerves. However, some researchers have observed a dual innervation from both pectoral and intercostal nerves.<sup>7,57-59</sup>

The sternalis observed in illustrative case number one of our study (**Figures 2a & 2b**) represents a unique type of muscle which does not fit into the classification of Jeleu et al.<sup>18</sup> The innervation of the sternalis in all our 3 cases (5 muscles) was solely by

**Table 1** - Frequency of sternalis in the subpopulations<sup>31</sup> of the geographic races from a review of the literature.

Population	Author year	Material adults/fetuses	n bodies examined	n bodies with sternalis found	Frequency per bodies examined %	Frequency per thoracic halves examined %
<b>European</b>						
English	Wood <sup>8</sup> 1866-1867		175	7	4	
Scottish	Turner <sup>6</sup> 1867		650	21	3.2	2.3
Irish	Macalister <sup>32</sup> 1875		350	11	3.1	2.3
Irish	Cunningham <sup>7</sup> 1888		358	16	4.5	
Irish	O'Neil & Folan-Curran <sup>17</sup> 1998	Adults	>2000	1		2.8
French	Le Double <sup>33</sup> 1890		809	37	4.6	
French	*Larget 1914		14	1	7.1	3.6
Belgian	‡Colson 1886		110	4	3.5	
Italian	Calori <sup>2</sup> 1888		160	4	2.5	
Italian	*Romiti & Sylvestri 1894		81	8	9.9	
Portugese	‡Tavares 1926-2927		265	5	1.9	
Portugese	†De Pina 1928		295	10	3.4	
Portugese	§Bruto de Costa 1950		1000		7.4	
Russian	Gruber <sup>34</sup> 1860		95	5	5.3	
Bulgarian	Jelev et al <sup>18</sup> 2001	Adults	102	3	2.9	4.2
Greeks	Kumaris <sup>35</sup> 1903		100	3		2
White Americans	Barlow <sup>21</sup> 1935	Adults	251	16	6.4	
White Brazilian	Locchi <sup>36</sup> 1930		125	8	6.4	
<b>Asiatic</b>						
Japanese	Adachi <sup>9</sup> 1897	Living	200	30	15	
Japanese	Adachi <sup>10</sup> 1909	Adults	183	27	14.8	10.4
Japanese	*Taniguchi 1930	Adults	204	22	10.8	7.4
Japanese	‡Nii 1931	Adults	117	12	10.3	6.8
Japanese	Taniguchi & Tochiara <sup>37</sup> 1932	Fetuses	300	37	12.3	7.5
Japanese	Hoshiba <sup>38</sup> 1936	Adults	140	10	7.1	3.9
Japanese	Watanabe <sup>39</sup> 1942	Living	1012	41	4.1	2.4
Japanese	Morita <sup>11</sup> 1944	Adults	205	21	10.2	6.6
Korean	‡Tanabe 1936		101	13	12.9	8.4
Chinese	*Nakano 1923		32	7	21.9	15.6
Chinese	*Wagenseil 1927	Adults	18	2	11.1	8.3
		Fetuses	27	2	7.4	3.7
North Chinese	‡Sakima 1932		34	8	23.5	16.2
North Chinese	Fukuyama <sup>19</sup> 1940	Adults	214	39	18.2	11.2
		Fetuses	71	8	11.3	6.3
Taiwanese	Shen et al <sup>15</sup> 1992	Adults	80	1	1.3	1.3
Taiwanese	Jeng & Su <sup>20</sup> 1998	Adults	207	2	1	1
Filipinos	Yap <sup>40</sup> 1921	Adults	136	5	3.7	2.9
		Fetuses	10	2	20	20
<b>African</b>						
African	Le Double <sup>41</sup> 1897		7	1	14.3	7.1
African	‡Loth 1912		58	1	12.1	
Black Brazilian	Locchi <sup>36</sup> 1930		91	12	13.2	7.1
Black American	Barlow <sup>21</sup> 1935	Adults	284	17	6	
<b>Indian</b>						
Indian	Misra <sup>12</sup> 1954	Adults	150	6	4	2.3
Indian	Rao & Rao <sup>23</sup> 1954	Adults	64	3	4.7	3.1
Indian	Kacker <sup>13</sup> 1960	Adults	75	6	8	6
<b>Arabs</b>						
Saudis	[1]Saeed 2002	Adults	75	3	4	3.3
n - number, *Cited by Taniguchi & Tochiara, <sup>37</sup> †Cited by Bralow, <sup>21</sup> ‡Cited by Fukuyama, <sup>19</sup> § Cited by Jelev et al, <sup>18</sup> [1]present study						

**Table 2** - Innervation of the sternalis muscle based on review of the literature.

Authors name	Years	n sternalis muscles with innervations noted	Pectoral nerves %	Intercostal nerves %	Double innervation from intercostal and thoracic nerves
*Hallet	1848	1		1	
Bardeleben <sup>42</sup>	1876	2		2	
*Malbranc	1878	2	1	1	
Krause <sup>43</sup>	1880	1	0	1	
Cunningham <sup>44</sup>	1884	1	1		
Shepherd <sup>45</sup>	1885	9	6 & 2?		1
Wallace <sup>46</sup>	1886	1	1		
Lamont <sup>47</sup>	1887	6	5		1
Dwight <sup>48</sup>	1887	4	2?	2	
Bardeleben <sup>49</sup>	1888	10		10	
Cunningham <sup>44</sup>	1884	17	17		
Le Double <sup>33</sup>	1890	4	1	3	
Fick <sup>50</sup>	1891	4		4	
Le Double <sup>41</sup>	1897		Yes		
Christian <sup>51</sup>	1898	3	1	2	1
Eisler <sup>52</sup>	1901	17	17		
Ruge <sup>53</sup>	1905		Yes		
Fick <sup>54</sup>	1917-1918			Yes	
Yap <sup>40</sup>	1921	11	9	2	
Locchi <sup>36</sup>	1930	20	20		
Taniguchi & Tochiara <sup>37</sup>	1932			Yes	
Patten <sup>55</sup>	1933-1934	2	2		
Slobodin <sup>56</sup>	1934-1935	6	3	3	
Barlow <sup>21</sup>	1935	17	3	13	1
Ura <sup>57</sup>	1937-1938		Yes		
Morita <sup>11</sup>	1944		Yes		
Fukuyama <sup>19</sup>	1940	32	15	17	
Misra <sup>12</sup>	1954	6		6	
Rao & Rao <sup>23</sup>	1954	4		4	
Kacker <sup>13</sup>	1960	6		6	
Blees <sup>3</sup>	1968	1		1	
Kitamura et al <sup>58</sup>	1985				
Kida & Kudoh <sup>59</sup>	1991	2	2		Yes
Shen et al <sup>15</sup>	1992	2		2	
O'Neill & Folan-Curran <sup>17</sup>	1998	2		2	
Jeng & Su <sup>20</sup>	1998	2	0	2	No
Jelev et al <sup>18</sup>	2001	2	0	2	No
**Saeed et al	2002	5	0	5	No
<b>Total (%)</b>		<b>202</b>	<b>104 &amp; 4? (53)</b>	<b>91 (45)</b>	<b>4 (2)</b>

\*cited by Cunningham,<sup>7</sup> \*\*present study, n - number, ? - doubtful

the intercostal nerves. Moreover, no communication was observed between the intercostal and pectoral nerves. Therefore, the present study strongly supports the observations of O'Neill and Folan-Curran<sup>17</sup> and Sadler,<sup>62</sup> suggesting the origin of sternalis from the ventral-longitudinal column of muscle arising at the ventral tip of hypomeres, represented by the infrahyoid muscles in the neck, rectus abdominis in the abdomen and occasionally by the sternalis in the thorax. Our sample is too small; however, to establish any significant comparison with multiple reports of a pectoral nerve supply of sternalis. Cunningham<sup>63</sup> proposed a nerve transference hypothesis for the rare innervation of sternalis by intercostal nerves; however, the current data shows that the innervation of the sternalis by intercostal nerves is not as rare as considered in the

past. Among the 200 sternalis muscles studied during the past 150 years, 45% have been found to be innervated by intercostal nerves (**Table 2**). The present study is the first report in the English literature to document the frequency of the sternalis muscle variation in KSA. For phylogenetic understanding of the human muscular system and to resolve the question of genesis of sternalis, the innervation of the sternalis muscle must be analyzed in detail at the level of its intramuscular nerve distribution. However, the clinical importance of the sternalis muscle in reconstructive myocutaneous flaps and the potential of misdiagnosis in the interpretation of craniocaudal mammograms, strengthen the need for its familiarity by anatomists, radiologists and surgeons.

Acknowledgment. We thank Prof. Amonoo-Kuofi for his critical advice, Mr. Veer for drawing the illustrations, and Mr. Mohammed Moazam for secretarial assistance.

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