

Research Article - Basic and Applied Anatomy

Prevalence of the sternalis muscle in Chilean population: A computed tomography study

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Abstract

The sternalis muscle is an anatomic variation that was first described in 1604. It has been studied in different populations worldwide, showing a widespread prevalence. The clinical importance of this muscle depends on mammographic evaluation that can lead to an erroneous diagnosis of breast cancer. Our objective is to determine the prevalence of sternalis muscle in Chilean population, characterizing it by gender and side of presentation using computerized tomography. To our current knowledge, there are no studies determining its prevalence using this method. No institutional review board approval was required for this analysis, which involved data made anonymous from men and women who underwent computerized tomography imaging for diagnostic purpose between January 2012 and February 2014. A retrospective radiological identification of the sternalis muscle was performed in 2288 axial computerized tomographies to determine the overall gender and side distribution. Data were analyzed using chi-square test. The sternalis muscle was present in 20 out of 2288 computerized tomographies, and its prevalence in the Chilean population was 0.87%. This muscle was found in male (12/1064, 1.12%) and female subjects (8/1224, 0.65%), no statistical difference between genders was found. Among people with the sternalis muscle, 12 (0.52%) presented it on the left side, 6 (0.26%) on the right side, and only 2 (0.09%) had bilateral sternalis muscle. The Chilean population has the lowest prevalence of sternalis muscle ever reported.

Key words

Sternalis muscle, anatomy, computerized tomography, clinical anatomy, gender, mammography.

Introduction

The sternalis muscle (SM) has been nominated as a supernumerary anatomic variation; it is a wide band of muscular tissue located in the anterior thoracic wall, where fibers travel near-parallel to the sternum, inferior to the clavicles, over the pectoralis major and pectoral fascia. It has received many names: rectus sternalis, parasternal, episternal, superficial abdominal rectus, among others (Scott-Conner and Al-Jurf, 2002; Arráez-Aybar et al., 2003; Bhat et al., 2009; Vaithianathan et al., 2011; Shiotani et al., 2012).

According to Arráez-Aybar et al. (2003), Bartholomeo Cabrolino in 1604 had mentioned the SM in his *Anatomes Elenchus Accuratissimus*. However, Du Puy (1726) was the first person to describe it in full detail. Important steps of SM history are shown in Table 1.

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Table 1. Main history events on sternalis muscle. According to Turner (1867), and Jelev et al. (2001).

Year	Author
1604	First mention by Cabrollo.
1726	Du Puy describes muscle associations.
1800	Sömmering describes muscle fiber direction in relation to major pectoralis.
1825	Meckel mentions the existence of aponeurotic connections.
1854	Strambio confirms the existence of aponeurotic connections.
1888	Bardeleben's first report on sternalis muscle innervation. Roubinowitch first observes a sternalis muscle on a living person.
1911	Pichler publishes the results of his work on 10,500 living people.
1912	Sclavounos describes muscular innervation in detail. Eisler reviews everything that was published.
1950	Costa studies 74 muscles in 1,000 corpses.
2001	Jelev, Georgiev and Surchev introduce a classification system based on insertions.

Even though the SM was first described in the 17th century, modern anatomy textbooks barely describe it, and it is almost unknown in clinical practice (as stated by Saeed et al., 2002; Scott-Conner and Al-Jurf, 2002; Arráez-Aybar et al., 2003)

It has been characterized in its different forms and positions with a length ranging from 2 to 14.4 cm and a width from 0.25 to 2.6 cm (Turner, 1867; Loukas et al., 2004).

Jelev et al. (2001) proposed a classification and definition that considered the SM to be unilateral or bilateral. At the same time, it should have the following characteristics: (1) it should be localized between the subcutaneous tissue of the anterior thoracic region and fascia pectoralis; (2) it should originate superiorly from the sternum or infraclavicular region; (3) it should be inserted inferiorly in the ribs, rib cartilage, external oblique muscle aponeurosis and sheath of the rectus abdominis muscle; (4) its innervation must come from the anterior root of the intercostal nerves. Another possible innervation from medial and lateral pectoral nerves has been mentioned (Jelev et al., 2001; Porzionato et al., 2012).

On the other hand, Saeed et al. (2002) state that the SM is always superficial to the rectus abdominis and does not continue as part of it.

Even though the SM does not appear to have a significant function, it is important to bear it in mind when evaluating mammograms, because one could misdiagnose it as a mammary cancer, as exposed by many authors (Bradley et al., 1996; Goktan et al., 2006; Marques et al., 2009). It is crucial to be familiar with this muscle to avoid confusion with pathology, such as extra-abdominal desmoid tumors, diabetic mastopathy, abscesses, hematomas, fat necrosis, and others; its presence may cause breast or chest asymmetry (Goktan et al., 2006; Nguyen and Ogawa, 2012). Computerized tomography (CT) and magnetic resonance imaging have been used for the differential diagnosis.

Sternalis muscle prevalence has been studied in different populations in the world. According to Shiotani et al. (2012), the highest prevalence is in China (23.5%) and the least in Taiwan (1%). In America, it accounts for 8% of the population, and its

unilateral presentation is twice more frequent than bilateral presentation (Saeed et al., 2002; Bhat et al., 2009). Some authors affirm that women have an increased likelihood to present bilateral SM. As far as we know, prevalence of SM has only been studied in latin america by Olave and del Sol (1990) in a 120 cadaveric study, but they barely found one SM case with bilateral presentation, making prevalence calculations of hard interpretation, also they were unable to show if there exists difference depending on gender and side, as shown by Turner (1867), Ge et al., (2014) and Snosek et al., (2014).

The purpose of this study was to determine the prevalence and laterality of the SM using CT and the possible correlation of these data with gender.

Material and Methods

Anonymous data from 2309 patients (1066 men and 1243 women) who underwent a CT imaging process between January 2012 and February 2014 were collected. All images were analyzed by physicians with at least five years experience in thoracic CT reading, sternotomized patients and mammary implants (2 male and 19 women images) were excluded from the study to avoid the possibility of external anatomy modification. The retrospective radiological identification of SM was performed using 2288 CT images obtained from five different radiological centers in Santiago, Chile.

The following protocol was used to analyze CT images:

1. Axial CT at levels T4-T5 were identified as positive if:
 - a. A triangular or flat image, 1-2 cm wide, was found between the skin and the deep fascia close to the sternal border.
 - b. The density was compatible with muscular tissue.
2. The presence of SM was verified at superior and inferior levels of CT.
3. Laterality was determined.
4. Data were stored and analyzed using Stata v.11.0 StataCorp. College Station, TX. with regard to gender, presence or absence of SM, laterality (right unilateral, left unilateral, or bilateral), using chi-square test, assuming significance for $p \leq 0.05$.

Results

A SM was present in 20 (0.87%) out of 2288 Chilean adults, 12/1064 males (1.12%) and 8/1224 females (0.65%). No statistical association between gender and SM was found using the chi-squared test. Among 20 patients with SM, six patients (30%) had the muscle on right side (Figure 1), twelve (60%) on the left side, and two (10%) on both sides (Figure 2). No association between gender and laterality of SM was found with this test. All bilateral cases were seen in men.

Discussion

The SM is a muscle of low prevalence, apparently of little clinical relevance, of unknown function and quite unrecognized by many physicians. Even though some

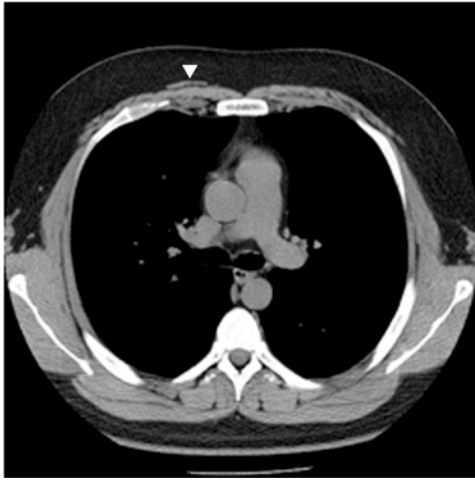


Figure 1. Sternalis muscle (white arrow) on the right side of thorax in a CT image.



Figure 2. Sternalis muscle (white arrows) on the right and left side of thorax in a CT image.

anatomists say that it could have a secondary function in inhalation, this function seems of little (if any) relevance to us, because even in cases when it is present, it usually appears unilaterally, as shown in this study, which only increases doubts regarding its role. However, it is important to know how to recognize the SM in images, because a person could misdiagnose it and confuse it with a mammary mass or an implant (Bradley et al., 1996), with potentially damaging repercussions of unnecessary biopsies or surgery. Pérez et al. (2008), Marques et al. (2009), and other studies have emphasized the importance of performing a correct identification at diagnostic imaging.

The prevalence of this muscle varies among countries: Korea (6.2-12.9%), Japan (4.1-15%), Europe (1.9-9.9%), Africa (4.2-14.3%), Taiwan (1.0-1.3%), Northern China (23%); (Jelev et al., 2001; Anjamrooz et al., 2013; Snosek et al., 2014) however, the reason for this variation is not yet clear.

Ethnic factors seem to be crucial, as one might suppose from the SM prevalence results shown in Asians, even though other factors must be considered to explain frequency in a specific population. Since it is a low prevalence anatomical variation, it is difficult to establish associations.

This study found on Chile a prevalence of the SM of 0.87%, the lowest percentage we know of, even lower than what Jeng and Su (1998) found in Taiwan. Consistent with the results shown in literature, this study found that unilateral cases are more frequent than bilateral cases. However, caution is advised when interpreting these data because of the very low number of cases. There was no significant difference in the prevalence of SM between genders in the Chilean population.

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References

- Anjamrooz S. H. (2013) Biceps sternalis: a Y-shaped muscle on the anterior chest wall. *J. Cardiothorac. Surg.* 8: 38-41.
- Arráez-Aybar L.A., Sobrado-Perez J., Merida-Velasco J.R. (2003) Left musculus sternalis. *Clin. Anat. N. Y.* 16: 350-354.
- Bhat K.M.R., Potu B.K., Gowda S. (2009) Sternalis muscle revisited [sic] in South Indian male cadaver: a case report. *Cases J.* 2: 6318-6320.
- Bradley F.M., Hoover H.C., Hulka C.A., Whitman G.J., McCarthy K.A., Hall D.A., Moore R., Kopans D.B. (1996) The sternalis muscle: an unusual normal finding seen on mammography. *AJR. Am. J. Roentgenol.* 166: 33-36.
- Cabrollo B. (1604) *Alphabeton anatomikon hoc est anatomes elenchus accuratissimus, omnes humani corporis partes, ea qua solent secari methodo, delineans. Accessere osteologia, obseruationesque medicis iuxta ac chirurgis perutiles.* Jacob Jouet, Geneva.
- Du Puy CT. (1726) *Histoire de l'Academie Royale des Sciences*, Amsterdam.
- Ge Z., Tong Y., Zhu S., Fang X., Zhuo L., Gong X. (2014) Prevalence and variance of the sternalis muscle: a study in the Chinese population using multi-detector CT. *Surg. Radiol. Anat.* 36: 219-224.
- Goktan C., Orguc S., Serter S., Ovali G.Y. (2006) Musculus sternalis: a normal but rare mammographic finding and magnetic resonance imaging demonstration. *Breast J.* 12: 488-489.
- Jelev L., Georgiev G., Surchev L. (2001) The sternalis muscle in the Bulgarian population: classification of sternales. *J. Anat.* 199: 359-363.
- Jeng H., Su S.J. (1998) The sternalis muscle: an uncommon anatomical variant among Taiwanese. *J. Anat.* 193: 287-288.
- Loukas M., Bowers M., Hullett J. (2004) Sternalis muscle: a mystery still. *Folia Morphol.* 63: 147-149.
- Marques E.F., Souza J.A., Graziano L., Bitencourt A.G.V., Senaga C., Fontes C.E.M. (2009) Sternalis muscle simulating a breast nodule. *Rev. Bras. Ginecol. Obstet.* 31: 492-495.
- Nguyen D.T., Ogawa R. (2012) The sternalis muscle - Incidental finding of a rare chest wall muscle variant during keloid excision-chest wall reconstruction. *Eplasty* 12: 32-38.
- Olave R., Del Sol M. (1990) The sternalis muscle: is its inclusion well supported in the nomina anatomica?. *Rev. Chil. Anat.* 8: 29-33.
- Pérez J., Pérez-Gumá J.E., Correa R., Rivera M., Castro A., Cedeño J., López M., Nazario L., Otero K., Quiles J., Sánchez, P. (2008) Breast mass or sternalis muscle? *P. R. Health Sci. J.* 27: 185.
- Porzionato A., Macchi V., Stecco C., Loukas M., Tubbs R.S., De Caro R. (2012) Surgical anatomy of the pectoral nerves and the pectoral musculature. *Clin. Anat. N. Y.* 25: 559-575.

- Saeed M., Murshid K.R., Rufai A.A., Elsayed S.E., Sadiq M.S. (2002) Sternalis. An anatomic variant of chest wall musculature. *Saudi Med. J.* 23: 1214-1221.
- Scott-Conner C.E.H., Al-Jurf A.S. (2002) The sternalis muscle. *Clin. Anat.* 15: 67-69.
- Shiotani M., Higuchi T., Yoshimura N., Kiguchi T., Takahashi N., Maeda H., Aoyama H. (2012) The sternalis muscle: radiologic findings on MDCT. *Jpn. J. Radiol.* 30: 729-734.
- Snosek M., Tubbs S.R., Loukas M. (2014) Sternalis muscle. What every anatomist and clinician should know. *Clin. Anat.* 27: 866-884.
- Turner W. (1867) On the musculus sternalis. *J. Anat. Physiol.* 1: 246-378.
- Vaithianathan G., Aruna S., Sugorthsbsi Rajila R.H., Balaji T. (2011) Sternalis "mystery" muscle and its clinical implications. *Ital. J. Anat. Embryol.* 116: 139-143.