On the innovative genius of Andreas Vesalius

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Chapter 5

Vesalius and the rotator cuff concept

Chapter based on article

Andreas Vesalius’ five hundreth anniversary: Initiation of the rotator cuff concept

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Chapter 5. Vesalius and the rotator cuff concept

Introduction
The shoulder rotator cuff is defined as a group of four scapulohumeral muscles and their tendons that act to stabilize the glenohumeral joint. The tendons of these supraspinatus, subscapularis, infraspinatus, and teres minor muscles blend with the glenohumeral joint capsule as they insert on the greater and lesser humeral tubercle [1, 2]. Besides stabilizing the shoulder by compressing the humeral head into the glenoid fossa, the four muscles endo- and exo-rotate the humerus relative to the scapula and provide muscular balance that allows precise coordination of movement [2].

The earliest published description of a rotator cuff tear was by Alexander Monro in 1788, when he described a “hole with ragged edges in the capsular ligament of the humerus” [2, 3], but so far, the first description of the rotator cuff per se remained unidentified [4, 5]. We came across an unmistakable record of this functional entity in the second of seven books compounding Vesalius’ De Humani Corporis Fabrca Libri Septum (De Fabrica). In this chapter, we present his record of this entity and discuss the shortcomings of his observations.

Materials and Methods
The text of Vesalius’ Book II - The Ligaments and Muscles of De Fabrica and the entire text of Heseler’s eyewitness report of the public dissection of three corpses by Vesalius in Bologna, Italy, in 1540, were searched for references to the four rotator cuff muscles and their function. In contemporary Galenic fashion, Vesalius categorized muscles according to their function and numbered them, rather than named them. Therefore, we identified the muscles by their current name on the base of their description provided by Vesalius. For this inventory we used the digital copy of the first print of De Fabrica (1543) [6] and its English translation provided by Richardson and Carman [7], while we used Heseler’s original text and its English translation as presented by Eriksson [8].

Vesalius’ description of the rotator cuff
Vesalius acknowledged that “the head of the humerus was made large and round and the socket of the scapula neither very broad or very deep” and that, therefore, “Nature produced certain processes of the scapula and various ligaments binding the bones together so that this loose joint should not be left without adequate protection nor the humerus be dislocated by some particular movement” [7]. Before describing the ligaments of the joint, however, he presented “most of the muscles that keep it together.” Among these muscles, Vesalius “showed the muscles which move the arm in a circle: they are placed round the head of the bone of the arm opposite to each other and they move the arm round in both directions” during the seventh of twenty-six demonstrations in Bologna [8]. In De Fabrica, Vesalius noted to “recognize three muscles that rotate the arm; they all take origin from the scapula and are implanted by means of broad tendons into the membranes containing the joint” [7]. He described these muscles as the fifth, sixth, and seventh “muscles moving the arm” (Figures 5.1 and 5.2). His descriptions fit the currently recognized supraspinatus muscle,
subscapularis muscle, and conjoined infraspinatus and teres minor muscles, respectively.

Vesalius furthermore observed that “the tendons of the three muscles that rotate the arm embrace the ligaments of the joint virtually in a complete circle” and that they all insert “into the ligament of the joint” [7]. This ligament, “the one that all joints have,” “surrounds the whole joint, being inserted into the root of the inner head of the humerus and also implanted into the mass of the whole outer head and the neck of each head.” [7] This description corresponds with the greater and lesser humeral tubercle as the area of insertion of the rotator cuff muscles.

Vesalius went on to describe the ligaments we now distinguish as the coracohumeral ligament and two of the three parts of the glenohumeral ligaments. He observed that their “function is to keep the humerus from slipping downward or outward from the socket in the scapula” and that these “three strong ligaments [...] bind the humerus into the socket of the scapula, in addition to the common bond that surrounds all joints like a membrane and is sometimes thin and sometimes thick” [7]. By his acceptance of the insertion of their tendons into that common bond of the joint Vesalius implicitly appreciated the binding structure of the rotator cuff tendons with its binding and stabilizing function. This way, he defined the rotator cuff concept avant la lettre.

Figure 5.1: Detail of Tabula XI of the famous muscle men in Vesalius’ *Humani Corporis Fabrica Libri Septem* showing the supraspinatus muscle (G) and the infraspinatus and teres minor muscles (I) with their insertion on the glenohumeral capsule (K)
Discussion
In 1543, Andreas Vesalius (1515-1564) described the anatomical parts and biomechanical functions of what is currently known as the shoulder rotator cuff. His description fully agreed with Antony F. DePalma’s remark that the glenohumeral “capsule (the superior, anterior and posterior portions of which blend with the tendinous insertion of the rotator muscles), together with the coracohumeral ligament, provides much stability to the joint” [9].

Vesalius’ failure to discriminate between the infraspinatus and teres minor muscles may easily be explained by their often being inseparable from each other [2]. The teres minor muscle was not recognized separately until after the publication of Fallopius [10]. Likewise, Vesalius discriminated only “three strong ligaments that bind the humerus in its socket.” We agree with Richardson and Carman that Vesalius probably failed to recognize the middle part of the glenohumeral ligament as it may be absent in up to 30 per cent of human shoulders [11].

Figure 5.2: Detail of Tabula VII in Vesalius’ Humani Corporis Fabrica Libri Septem showing the subscapularis muscle (Γ) and its insertion on the glenohumeral capsule (K)
Vesalius’ failure to record that the rotator cuff muscles help provide the muscular balance that allows precise coordination of movement may be explained by his lack of muscle function examination \textit{in vivo}. In general, Vesalius’ descriptions of muscle functions were mechanically basic and lacking the concept of movements resulting from simultaneous action of multiple muscles. As such, he ascribed the rotating function of the arm exclusively to the rotator cuff muscles whereas the biceps brachii, pectoralis major, deltoid, lattisimus dorsi, and teres major muscles are currently considered to help rotate the arm.

\textbf{Conclusion}

We conclude that Vesalius recognized the need of a structure, or structures, that prevent dislocation of the shoulder inherent to the morphology of the humeral caput and scapular socket. He recorded “three strong ligaments” and the “three muscles that rotate the arm” of which the tendons completely “embrace the ligaments of the joint” as such structures. In doing so, Vesalius was the first to record the rotator cuff concept.
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References