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Andreas Vesalius, the Prince of Anatomy: An Anatomical Analysis of the Trachea, Rectus Abdominis Muscle, and Sacrum in *De Humani Corporis Fabrica*

Andreas Vesalius el Príncipe de la Anatomía: Un Análisis Anatómico de la Tráquea, del Músculo Recto del Abdomen y del Hueso Sacro en *De Humani Corporis Fabrica*

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SUMMARY: Andreas Vesalius (1514–1564), a central figure of the Anatomical Renaissance, challenged Galenic teachings with an empirical approach based on the direct dissection of the human body. His masterpiece, *De Humani Corporis Fabrica* (1543), revolutionized the study of anatomy and marked a milestone in the visual representation of the body. This article celebrates his legacy in the context of World Anatomy Day, which coincides with the XXI Congreso Panamericano de Anatomía (Bucaramanga, Colombia, 2025). This article highlights his historical impact and conducts an exhaustive analysis of some of his anatomical illustrations. The work examines his depictions of the trachea, rectus abdominis muscle, and sacrum, identifying differences with current knowledge, such as the variability in the number of tracheal cartilages, the atypical insertion of the rectus muscle, and the description of six sacral vertebrae. It is noteworthy that Vesalius consolidated the principles of direct observation and empirical verification, challenging the unquestionable authority of Galen and laying the foundations of modern anatomy.

KEYWORDS: History of anatomy; Trachea; Rectus abdominis muscle; Sacrum; Anatomical variation.

INTRODUCTION

Andreas Vesalius corresponds to the Latinized name of Andries van Wesel, who was born in Brussels, Flanders (present-day Belgium), on December 31, 1514 (Saunders & O'Malley, 1973). His training as a physician and anatomist allowed him to create his masterpiece *De Humani Corporis Fabrica* (1543). Like any other student of his time, Andreas Vesalius initially accepted the teaching of anatomy from Galen of Pergamon (129-216). Although Vesalius' anti-Galenism has been greatly exaggerated and constitutes a profound misunderstanding of his thought and his time, it is possible to establish from fragments in *De Humani Corporis Fabrica* (Vesalius, 1543) that Vesalius was never completely opposed to the Galenic system. On the contrary, he attempted to reconcile or correct it when his anatomical descriptions did not agree with direct observation, a criterion that any rigorous researcher should adopt.

"As the gods love me, I, who yield to no one in my devotion and reverence for Galen, cannot and should not enjoy greater pleasure than praising him." Andreas Vesalius

Vesalius pointed out that the human body was not as Galen had described it, so he represented the heart without bony elements (Fig. 1A), identified the sternum as a structure composed of six bony segments, and described the fusion of its three constituent parts: manubrium, body of sternum,

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and xiphoid process (Fig. 1B). He also refuted Galen's claim that the patella was entirely cartilaginous (Fig. 1C), and questioned the idea that the anorectal veins were a branch of the inferior vena cava, among other things. Thus, authors such as Kusukawa (2024) have estimated that Vesalius could have corrected Galen in more than two hundred anatomical structures. These observations not only reflect Vesalius' deep commitment to empirical evidence but also his intention to advance anatomical knowledge, even if this meant breaking with tradition and correcting it where necessary.

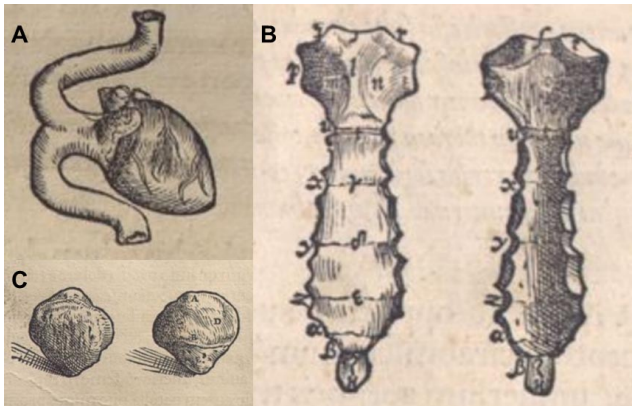

Fig. 1. Representations made by Andreas Vesalius in *De Humani Corporis Fabrica* (1543). A. Heart; B. Sternum; C. Patella.

At the General Assembly of the 19th Congress of the International Federation of Associations of Anatomists (IFAA), held in London in 2019, the participants declared October 15 as World Anatomy Day, commemorating the death of Andreas Vesalius and recognizing the importance of his contributions. This initiative seeks to preserve and promote the legacy of a fundamental science, encouraging its global celebration through various activities. Thus, the organization and dissemination of these initiatives constitute an essential responsibility for the entire community of anatomists (Turamanlar, 2025).

In this context, the objectives of this document are to analyze, vindicate, and expand on the historical elements associated with the "Prince of Anatomy" within the framework of World Anatomy Day, celebrated on October 15, which will coincide with the XXI Congreso Panamericano de Anatomía, scheduled to take place from October 14 to 18, 2025, in Bucaramanga (Colombia). Likewise, this document proposes an analysis of selected images from the book *De Humani Corporis Fabrica* (Vesalius, 1543).

MATERIAL AND METHOD

From the book *De Humani Corporis Fabrica* (Vesalius, 1543), we analyze the anatomical illustrations contained in said treatise, focusing specifically on those that represent the trachea, the rectus abdominis muscle, and the sacrum. The illustrations selected for analysis were examined not only for their descriptive and scientific value, but also for the anatomical understanding prevalent at the time, as well as for the technical precision with which they depicted the aforementioned structures.

RESULTS

Three models representing the trachea were identified, with several tracheal cartilages (TCs) numbering 24, 14, and 13. The representations show TCs with regular and homogeneous morphology along the entire trachea (Fig. 2). In one of the models, however, the tracheal carina and the main bronchi are absent, and the trachea continues directly with the intrapulmonary bronchi (Fig. 2C).

Regarding the rectus abdominis muscle, two distinct models were described. In the first representation, the muscle extends to the clavicular region (Fig. 3A), which would represent an extraordinary case. In contrast, in the second representation (Fig. 3B), six tendon intersections are observed.

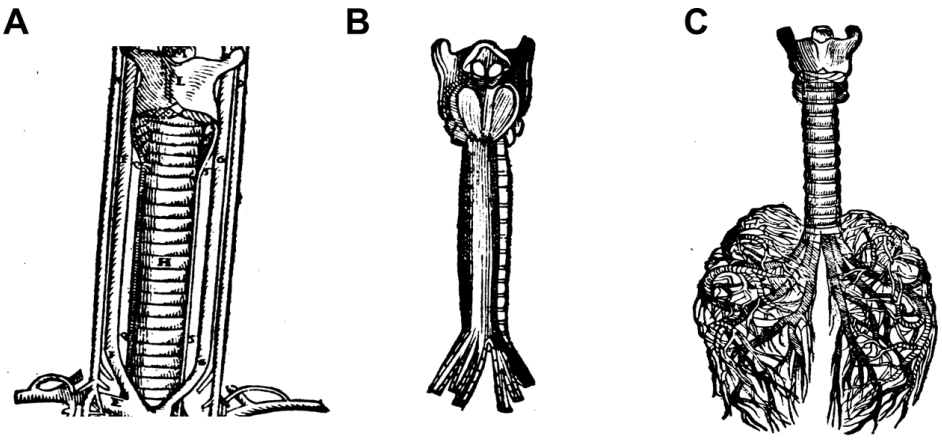

Fig. 2. Anatomical illustrations of the trachea from Vesalius' work (1543). A. Trachea with 24 tracheal cartilages; B. Trachea with 14 tracheal cartilages; C. Trachea with 13 tracheal cartilages and no carina of trachea, which has direct continuity with the intrapulmonary bronchi.

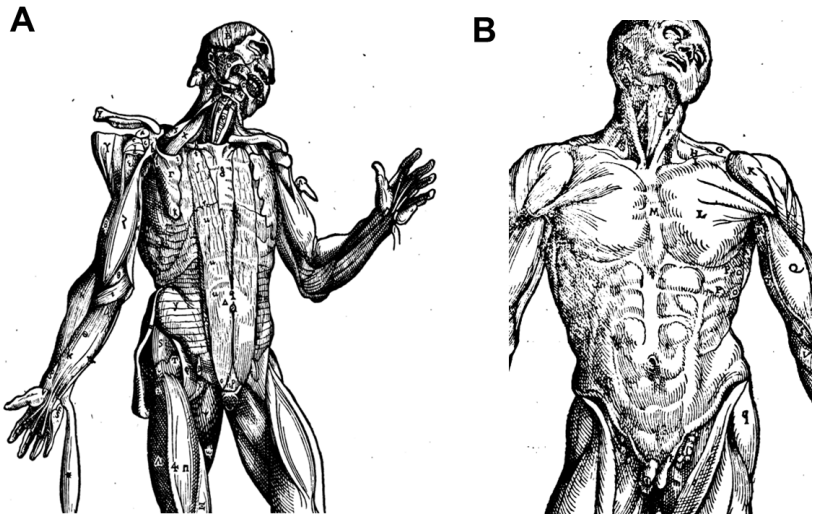

Fig. 3. Anatomical contrast of the rectus abdominis muscle in *De Humani Corporis Fabrica* (1543). A. clavicular continuity; B. multiple tendon intersections.

Two illustrations depicting the sacrum were found, showing this bone structure composed of six vertebrae, five transverse ridges on its pelvic surface, five pairs of anterior sacral foramina, and, consequently, five posterior ones (Fig. 4).

Fig. 4. Sacral configuration of six vertebral segments in *De Humani Corporis Fabrica* (1543).

DISCUSSION

Andreas Vesalius distinguished himself by breaking with the dominant anatomical tradition, challenging the concepts and practices inherited from antiquity. This break is evident both in the initial image and in the preface to *De Humani Corporis Fabrica* (1543), where Vesalius personally performs the dissections during his anatomical demonstrations (Fig. 5). With this gesture, Vesalius openly questioned the conventional format of the time, characterized by a strict division of labor: the lecturer, a learned physician, presented from a raised pulpit; the barber, without technical training, performed the cuts with a large knife; and the ostensor, usually a student or assistant instructor, pointed out the anatomical structures with a cane. By assuming all these functions himself, Vesalius claimed direct observation as the basis of anatomical knowledge, thus marking a decisive turning point in the scientific practice of the Renaissance. In addition to personally performing the dissections during his lectures, Vesalius used anatomical tables that he designed (Fig. 6) and published under the title *Tabulae Anatomicae Sex* (1538). According to Saunders & O'Malley (1973), this publication was, in part, a response to the unauthorized circulation of its illustrations in various academic circles.

The works *Tabulae anatomicae sex* (1538) and *De Humani Corporis Fabrica* (1543), in which Vesalius questioned inherited anatomical practices and criticized traditional methods, provoked an angry reaction from some Galenists. One of those who fiercely attacked him was his Parisian teacher Jacobus Sylvius (1478-1555), who felt obliged to defend Hippocrates and Galen, whom he considered the most perfect men. For this reason, he launched severe epithets against Vesalius, as shameless, impious, slanderer, and ignorant, in his text *Vaesani cuiusdam calumniarum in Hippocratis Galenique rem anatomicam depulsio* (1551).

Due to attacks from his detractors, Vesalius abandoned anatomical research, even going so far as to burn numerous scientific notes (Saunders & O'Malley, 1973). However, his growing prestige as an anatomist and physician attracted the attention of the Spanish imperial court, which appointed him personal physician to Charles V (Adam, 1620). In 1556, Philip II, successor to Charles V, assumed power and remained in Brussels until 1559, when Vesalius accompanied the court to Spain. Unfortunately for him, some traditional doctors and conservative courtiers viewed his methods with suspicion, which, according to Pagel (1898), further alienated him from his anatomical studies and prompted him to undertake a pilgrimage to Jerusalem.

Another version, though possibly legendary, states that Vesalius was in Spain under the protection of a nobleman who died suddenly. Vesalius requested permission from the family to perform an autopsy and clarify the cause of death. During dissection, he found that the heart was still beating. Shocked, his family denounced him for murder and impiety before the Inquisition. Although authorities confirmed that

Fig. 5. Image from the text *De Humani Corporis Fabrica* (1543), where Andreas Vesalius dissects in the center of the scene.

Fig.6. First illustration in *Tabulae anatomicae sex* (1538), dedicated to Narcisso Parthenopeo.

the person was already dead, the error was considered serious due to the reputation of the physician involved. The Inquisition attempted to impose an exemplary punishment, and only thanks to the intervention of King Philip II did Vesalius avoid condemnation (Adam, 1620). Life at the Spanish court was not conducive to scientific study, and the influence of the Church was suffocating; the Inquisition's dagger struck the very core of mental life, and its torch acted as a sterilizing flame that swept away intellectual activity (Moores-Ball, 2023). Thus, he was granted forgiveness on the condition that he undertake a pilgrimage to Jerusalem and Mount Sinai. Although both versions differ, they agree that Vesalius' pilgrimage to Jerusalem was motivated by the hostility of the Spanish court and the medical establishment, which hindered his every move. During the return from Jerusalem, according to Saunders & O'Malley (1973), the ship struck disaster near the Greek island of Zakynthos, and the turbulent waters swept him away, leading to his death on October 15, 1564.

Andreas Vesalius' contributions to anatomical knowledge of the human body span from the description of typical structures to the recognition of anatomical variants that were scarcely documented at the time, such as the fabella (Duque-Colorado *et al*., 2024), demonstrating the indisputable impact of his research. However, as the author himself points out in the preface to *De Humani Corporis Fabrica* (1543), this approach loses validity when scientific authority lacks internal coherence. Galen, for example, corrects himself over time, allowing later writers to refute him further by invoking a higher authority: empirical evidence, that is, truth (Gielen & Goyens, 2018). In this way, Andreas Vesalius broke the chains of knowledge imposed by tradition and opposed ancient authorities, an attitude we share not only to avoid the persistence of anatomical concepts that are no longer considered in the same way today, but also to emphasize that in anatomy the processes of updating and discussing terminologies must be understood as a continuity and evolution of knowledge, rather than as radical ruptures or abrupt revolutions (García-Orozco *et al*., 2024).

Vesalius, in *De Humani Corporis Fabrica* (1543), illustrated the trachea using models showing 24, 14, and 13 TCs, which is not observed in normal human anatomy, since

the trachea in normal conditions consists of several TCs ranging between 15 and 22 (Testut & Latarjet, 1929; Landing & Dixon, 1979; Standring, 2016; Premakumar *et al*., 2018). Researchers first recognized the clinical relevance of having fewer than 15 TCs as a structural abnormality in the 20th century. Landing & Dixon (1979) were the first to associate this feature with congenital malformations, specifically with congenital short neck (brevicollis) and Klippel-Feil syndrome. Later, Sein *et al*. (1985) linked it to DiGeorge syndrome, and Wells *et al*. (1989) linked it with various skeletal dysplasias. These findings established the number of TCs as a useful anatomical feature for recognizing congenital syndromes. Regarding the homogeneous morphology of the TCs represented by Vesalius (1543), Philibert-Constant Sappey already pointed out in 1853, in his Traité d'anatomie descriptive, that the TCs have varied shapes and that no two are exactly alike in the same trachea. On the other hand, in more recent experimental studies, Premakumar *et al*. (2018) observed that most TCs exhibit diverse morphologies, including S, L, H, U, X, A, V, M, or W shapes, as well as bifurcated, fenestrated, or incomplete configurations. In addition to the reduced number and homogeneous morphology of TCs, Vesalian representations omit fundamental anatomical structures of the lower airway, such as the carina of trachea, resembling a cartilaginous spur that allows its bifurcation (Standring, 2016), thereby giving rise to the main bronchus, right, and left. Although there are cases in which the carina of trachea is absent, as in Type III tracheal agenesis (Faro *et al*., 1979), this condition does not resemble the representation made by Vesalius, since, in this type of configuration, the main bronchus arise directly from the esophagus. In the case of Vesalius, although he may have depicted specific anatomical variants, some of the configurations illustrated are not supported in current literature. Furthermore, regarding the number of TCs, none of their descriptions match normal human anatomy, leading us to consider this representation an anatomical inaccuracy.

Along these same lines, we distance ourselves from the illustrations of the rectus abdominis muscle in *De Humani Corporis Fabrica* (1543), where extensions of this muscle up to the clavicle and supernumerary tendon intersections are illustrated. In normal human anatomy, the rectus abdominis muscle inserts into the thorax via three fascicles. The lateral, wider, and superior part inserts into the lower margin of the cartilage of the fifth rib; the intermediate part inserts into that of the sixth, and the medial and lower part inserts into that of the seventh rib. In some cases, it may extend to the xiphochondral ligament or even the xiphoid process (Testut & Latarjet, 1929; Standring, 2016). The illustration made by Vesalius agrees with the description of the rectus abdominis muscle that Henri Lenoir presented before the Société Anatomique de Paris (1832), where he noted that in an adult, the rectus abdominis muscle extended to the clavicle, an arrangement frequently observed in quadruped primates. At present we have not found any literature to support these findings, so we consider that in both cases it was a matter of confusion, where the authors probably observed the sternalis muscle an anatomical variation that, in some individuals, may originate in the sheath of the rectus abdominis muscle or the fourth or fifth rib and extend to the clavicle. These characteristics have led some anatomists to regard it as a dependency of the rectus abdominis muscle (Le Double, 1897). Regarding its tendon intersections, their most constant number in humans is three, one located at the free end of the xiphoid process, another at the level of the navel and a third approximately halfway between both (Testut & Latarjet, 1929), an observation that agrees with more recent findings, where it has been identified that the majority of the analyzed population had three tendon intersections in the rectus abdominis muscle, while in 1.85 % (Anita *et al*., 2015) and 6.25 % (Broyles *et al*., 2018) of cases, up to four were found. In agreement, Le Double (1897) points out that, exceptionally, two, five, or even six tendon intersections can be found, the latter number also seen in young gorillas. Furthermore, it indicates that in humans, more than one subumbilical intersection is never observed, and when present, it tends to disappear. A description that contrasts with the Vesalian representation, in which Vesalius illustrates six tendon intersections, three of them arranged in a subumbilical pattern. Considering the above, Vesalius's illustration does not represent the normal anatomy of the rectus abdominis muscle, but rather a probable anatomical variant. It may also have been an exaggerated representation of this muscle, or it probably represented a transposition from animal to human anatomy.

Regarding the sacrum, also known as the great vertebra, it is a bone formed by the fusion of five sacral vertebrae in adulthood, which articulates with the iliac bones and the fifth lumbar vertebra through a fibrocartilaginous disc (Duque-Parra *et al*., 2022). On the pelvic surface of sacrum, there is a bony column irregularly segmented by four transverse ridges, which represent the fusion of the five sacral vertebrae. At their ends lie the anterior sacral foramina, arranged in four on each side, continuing with the posterior sacral foramina, whose size is smaller than that of the anterior ones. However, this morphological configuration is not constant, since anatomical variations in the number of fused vertebrae have been reported, with excess sacral vertebrae occurring more frequently than deficiencies (Le Double, 1912). This variation, known as the lumbosacral transitional vertebra, has a reported prevalence of up to 36 % in specific populations (Apaydin *et al*., 2019) and is associated with Bertolotti syndrome (Bertolotti, 1917; Ju *et al*., 2024). Thus, the illustration made by Vesalius does not reflect the current

anatomical configuration of the sacrum, but rather a morphological variation attributable to a lumbosacral transitional vertebra, which led to this fusion, allowing the identification of five transverse ridges and five anterior and posterior sacral foramina. Likewise, Vesalius's representation of the anterior and posterior sacral foramina show the same size, an aspect that does not agree with the morphometric characteristics of these foramina in a typical sacrum, whose diameter is greater in the anterior sacral foramen (Testut & Latarjet, 1929; Bagheri & Govsa, 2019), a difference attributable to the fact that the anterior roots of the sacral nerves, which emerge through the anterior foramina, are thicker than the posterior roots, which requires more space for their passage.

Based on what has been discussed in this chapter, we consider that Vesalian representations present discrepancies concerning the anatomical configuration recognized today; however, it is essential to evaluate these descriptions within the historical context in which they were produced, where the technical and conceptual limitations of their time conditioned the anatomical interpretation of the time. Furthermore, although the anatomical descriptions developed by early anatomists may be subject to criticism, they played a fundamental role in the development of modern medicine. The work of these pioneering anatomists not only bequeathed a structural basis for anatomical knowledge but also reaffirmed the importance of rigorous observation and systematization of the human body, principles that remain essential pillars of medical and morphological research today (Duque-Colorado *et al*., 2025).

"we yield to no one in our devotion
and reverence for Vesalius."

CONCLUSION

Andreas Vesalius critically reviewed Galen's anatomy, introducing an experimental approach that represented a fundamental change in the study of human anatomy, distinguishing it from the anatomy of other species. However, some anatomical discrepancies persist in some illustrations in his work *De Humani Corporis Fabrica*, for example, inaccuracies in the representation of the trachea, the rectus abdominis muscle, and the sacrum, among others. However, his legacy remains a cornerstone in the history of anatomy, marking the beginning of an era in which direct observation, empirical evidence, and questioning established authority became guiding principles of medical science. Nearly five centuries after his work, Vesalius continues to inspire generations of anatomists and scientists by challenging the established norm in his search for a more precise understanding of the human body.

DUQUE-PARRA, J.; DUQUE-COLORADO, J.; OTTONE, N. E.; BALLESTEROS-ACUÑA, E.; ALGIERI, R. D. & DEL SOL, M. Andreas Vesalius el príncipe de la Anatomía: Un análisis anatómico de la tráquea, del músculo recto del abdomen y del hueso sacro en *De Humani Corporis Fabrica*. *Int. J. Morphol., 43(4)*:1402-1408, 2025.

RESUMEN: Andreas Vesalius (1514-1564), figura central del Renacimiento anatómico, desafió las enseñanzas galénicas mediante un enfoque empírico sustentado en la disección directa del cuerpo humano. Su obra maestra *De Humani Corporis Fabrica* (1543) revolucionó el estudio anatómico y marcó un hito en la representación visual del cuerpo. El presente artículo exalta su legado en el contexto del Día Mundial de la Anatomía que coincidirá con el XXI Congreso Panamericano de Anatomía (Bucaramanga, Colombia, 2025), destacando su impacto histórico y realizando un exhaustivo análisis de algunas de sus ilustraciones anatómicas. Se examinan las representaciones de la tráquea, el músculo recto del abdomen y el hueso sacro, identificando diferencias comparativas con el conocimiento actual, como la variabilidad en el número de cartílagos traqueales, la inserción atípica del músculo recto del abdomen y la descripción de seis vértebras sacras. Cabe destacar que Vesalius consolidó los principios de observación directa y verificación empírica, desafiando la autoridad incuestionable de Galeno y cimentando las bases de la anatomía moderna.

PALABRAS CLAVE: Historia de la anatomía; Tráquea; Músculo recto del abdomen; Hueso sacro; Variación anatómica.

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