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COVER EDITORIAL

Iulius Casserius, a relatively underestimated anatomist: his contributions to brain's anatomy

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Abstract
Iulius Casserius is to be remembered for his excellent contributions in Anatomy and especially in Neuroanatomy. His persistent and meticulous scientific anatomical work resulted in the first record of the arterial circle of the brain 37 years before the comprehensive description by Thomas Willis. Casserius' great interest in the human brain led him to the discovery of plenty anatomical structures before their official documentation. Casserius was an excellent teacher and anatomist of a humble origin, who managed to be distinguished among other famous physicians of his era.

Keywords Casserius · Neuroanatomy · History · Medicine

Short biographical data of Iulius Casserius

Iulius Casserius who was born around 1552 at Placentia from which town surnamed Placentinus was a celebrated Italian surgeon and anatomist. Casserius' family was in poverty, and he entered into service as a servant to Fabricius de Aquapendente of Padua, who made him his pupil and assistant and at length coadjutor in the professorship of Anatomy [8, 23]. Casserius took his degree in Medicine presumably in 1580 and provided private lessons on anatomy at his home and served as preparator—demonstrator for the public lectures—dissections of Fabricius in Padua. Moreover, he practiced medicine and surgery successfully at Padua, and his scientific value was recognized so that he was placed as member of the examination committee for the title of surgeon [21, 26, 28]. Fabricius in the opinion of Douglas excelled in philosophy, whereas Casserius in anatomy [8]. Casserius' reputation as teacher in private lessons was so great, that university, after Fabricius' opinion, prohibited the private lessons made by Casserius [15] (Fig. 1). At the year 1597–1598, Fabricius due to lack of cadavers reduced the number of his public lectures, whereas Casserius made private lessons with 5-week duration with great success [26]. During the period 1605–1608, Casserius continued his teaching activity at his home with private lessons, while Fabricius provided only few public lessons [21].

Meanwhile, Casserius published three works: "De vocis auditusque organis Historia anatomica" (1600–1601) [6], "Pentaestheion, hoc est, De quinque sensibus liber, Organorum Fabricam" (1609) [7], and his third work entitled "Iulii Casseri Placentini Tabulae Anatomicae LXXIIX…" [5] was published in 1627 from Spigelius' student, Daniel Bucretius. The competition between Casserius and his teacher, Fabricius, was so strong, that Fabricius published almost simultaneously a similar work entitled "De Visione, Voce, Auditu" (1600) [11].

In 1609, the teaching of Anatomy was separated from that of Surgery, and thus, Casserius received the position of Lecturer of Surgery, whereas Fabricius hold the chair of Anatomy [21]. In 1613, Fabricius suggested Giulio Cesare Sala as his successor in the teaching of anatomy; however, the university suggested Casserius for that position. In January 1616, Casserius for the first only time taught Anatomy as public Lecturer at the famous theater that had been established by Fabricius in 1594. Unfortunately, on March 1616, Casserius contracted a fever and died, whereas his old teacher died after 3 years in 1619 [26].

Casserius' discoveries on the brain's anatomy

Herophilus of Calcedon (335–280 BC) described along the base of the brain a vascular network that he called "rete

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Fig. 1 Iulius Casserius (1522; 1616), Italian anatomist and surgeon at the University of Padua

mirabile." It was Galen of Pergamum (131–201 AD) that gave an accurate prescription of "rete mirabile" in his work "On the usefulness of the parts of the body." Galen considered that this rete slowed the passage of blood transforming the vital pneuma to animal pneuma. It is now known that such a "rete mirabile" does not appear in humans, but appear in ungulates [1]. In particular Galen as regards "rete mirabile" wrote: "Τό δή καλούμενον ὑπό τῶν ἀνατομικῶν δικτυοειδές πλέγμα μέγιστον θαῦμα τῶν ἐνταυθοῖ τέτακται, περιλαμβάνον μέν ἐν κύκλω και αὐτόν τον ἀδένα, παρῆκον δέ καί εἰς τον πίσω μέχρι πλείστον. πᾶσα γάρ ὀλίγον δεῖν ἡ τοῦ ἐγκεφάλου βάσις ὑποτεταγμένον ἔχει τοῦτο το πλέγμα. Ἔστι δ'οὐχ ἁπλοῦν το δίκτυον, ἀλλ'ὡς εἰ καί ταῦτα τά δίκτυα τῶν ἁλιέων πλείω λαβών ἐπ'ἀλλήλοις ἐκτείνοις," which means: "The so-called reticular plexus by the anatomists is the most wonderful from the structures located at this area. It surrounds circularly the gland (hypophysis) and extends for a long to the posterior regions. Almost the entire brain's base has underneath the whole plexus. That plexus is not so simple, but resembles to many nets of fishermen, placed the one upon to another" [12]. Later in, Mondino de Luzzi, the "Restorer of Anatomy" (1270–1326 AD) in his historical treatise called "Anothomia" written in 1316 and dominated along with the Galen's texts till the era of "Fabrica" of Andreas Vesalius (1543), provided a description of the "rete mirabile" being in accordance with the Galenic concepts [9]. Jacobus Berengario da Carpi (1460–1530 AD), professor of Surgery at Bologna from 1502 to 1527 in his work "Commentaria Super Anatomia Mundini" published in 1521, claimed that such a "rete mirabile" does not exist in humans. He also, stated: "…I believe that Galen has imagined the rete mirabile and he never saw it and I believe that other men after Galen believe in the rete mirabile more because of the opinion of Galen than because of the fact…" [10]. Andreas Vesalius (1514–1564 AD), the famous anatomist, the so-called Reformer of Anatomy, wrote as regards the "rete mirabile" the following: "…For the soporal (carotid) arteries quite fail to produce such a plexus reticularis as that which Galen recounts" [24]. In his famous treatise, Vesalius provided a figure demonstrating an arterial trunk with branches on each side of the hypophysis not forming the well-known arterial circle [29].

It is Gabriele Fallopio (1523–1562 AD) that provided an arterial network at the base of the skull resembling to the arterial circle, a description more accurate of that of Vesalius. Fallopio in his epic work "Observationes Anatomicae" that was published in 1561 stated: "(the basilar artery) divides into two branches (thus the posterior cerebral arteries) which one creeps along the right side of the sella… There arrived, each divides into an infinite number of branches… it (thus the internal carotid artery) enters the cavity below the basis of the brain… and divides there entirely into two branches of which the interior (thus the anterior cerebral artery) joins up with its interior equivalent of the other side" [17]. As it is apparent, Fallopio mentioned the existence of the anterior communicating artery, failing however to prescribe the posterior communicating artery.

Iulius Casserius (1552–1616 AD) in his 77 "Tabulae Anatomicae" that were incorporated in "De Humani Corporis Fabrica Libri Decem," the work written by Spigelius and published in 1627 by Daniel Bucretius, Spigelius' student, and in Table X provided a complete semicircle with a posterior communicating artery on the left (Fig. 2a). In Table X of the Liber X, most authors detected only a thin posterior communicating artery on the left hemisphere [16, 17]. From the study of the Table X, we consider that the anatomical structure labeled with the letter C corresponds to the anterior communicating artery. It is interesting that Casserius considered that all the arterial structure at the base of the brain corresponds to the "rete mirabile" of Galen. However, it is known that the legends to the Casserius' "Tabulae Anatomicae" were written by Daniel Bucretius and not by Casserius. Thus, it seems that Bucretius supported the existence of the "rete mirabile," although such a structure has already been denied by da Carpi, Vesalius, and Fallopius. Bender et al. [2] noticed that Figure II of Table IX corresponds to a sequential dissection of the same brain. They found that both the posterior communicating arteries are clearly shown joining the internal carotid arteries, with the right posterior communicating artery (right side of the image) being larger in diameter (Fig. 2b). From a comprehensive study of

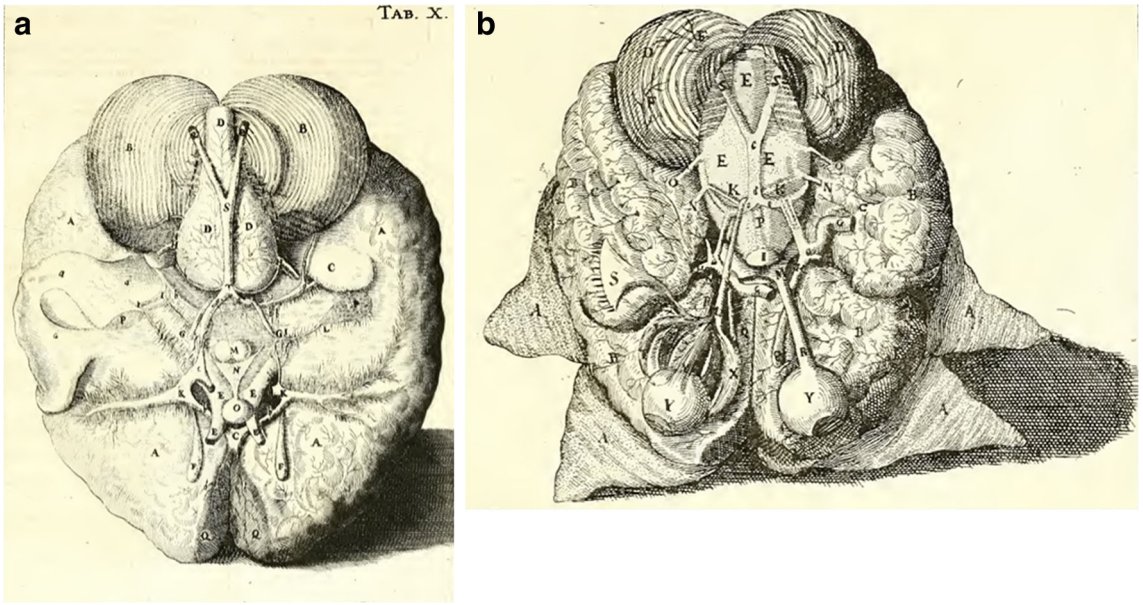


Fig. 2 **a** In Table X of the work of Casserius "Tabulae Anatomicae," a thin posterior communicating artery is located at the left. **b** In Figure II of Table IX, both the posterior communicating arteries are clearly visible

"Tabulae Anatomicae," we observed that in another figure, Figure II of the Table VIII of Liber X of Iulius Casserius' "Tabulae Anatomicae," the posterior communicating arteries are well designed with the right one (the right side of image) being larger in diameter. Unfortunately, the posterior cerebral as well the internal carotid arteries were hidden by the meningeal diaphragm of the turcica sella (Fig. 3).

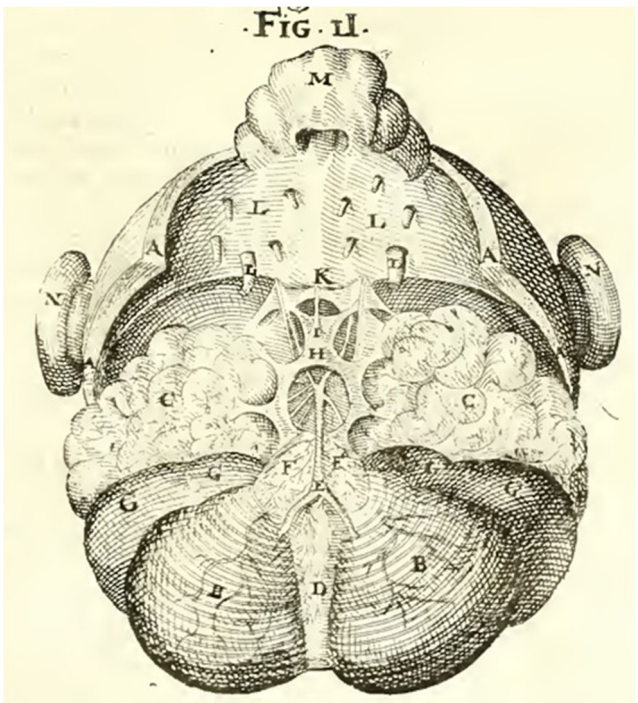


Fig. 3 In Figure II of the Table VIII of the work "Iulii Casseri Placentini Tabulae Anatomicae…," the posterior communicating arteries are well designed with the right one (the right side of image) being larger

Thus, 37 years before the first comprehensive description of the arterial circle of the brain by Thomas Willis in his marterpiece "Cerebri Anatome" in 1664 in which Willis stated: "…the carotid arteries of one side in many are united with the carotids of the other side; besides the vertebrals of either side among themselves, and are also inoculated into the posterior branches of the carotids before united," it was Casserius that provided to the Medicine the first account of that structure found at the base of the brain [30].

It is likely that Casserius many years before Monro had designed the interventricular foramen. Although Spigelius in his treatise "De humani corporis fabrica, libri decem" that was published in Venice in 1627 wrote: "…From which (two lateral ventricles) through the anterior passage of the so-called third ventricle then through the pelvis (it) transmits gradually to the pituitary gland," from which text it seems that Spigelius was not aware of the presence of the interventricular foramina [25], Casserius in Figure II of his Table V designed the interventricular foramen and at the corresponding legend, that was presumably written by Bucretius, he named it "meatum anteriorem tertii ventriculi" [4] (Fig. 4). After Casserius, similar terms have been utilized for the foramen of Monro, such as "orifice of third ventricle" by Bartholini in 1662 or "ostium anterius ventriculi tertii" by Haller in 1762 [27]. Thus, Casserius designed and Bucretius named 156 years prior to Alexander Monro Secundus in 1783 the interventricular foramen. In specific, Monro wrote as regards that foramen: "…to lead to the forepart of an oval hole, large enough to admit a goose quill, under the forepart of the fornix. From this hole, a probe can readily be passed into the other lateral ventricle, shewing in the first place that the two lateral ventricles communicate with each other" [18].

Moreover, Casserius in Figure II of Table IV of liber X of his "Tabulae Anatomicae" provided a marvelous representation of the fornix, and especially of the corpus and crus (Fig. 5a). That drawing is absolutely more accurate and descriptive than the fornix in Vesalius' "Fabrica" in Table 68 [14] (Fig. 5b). Fornix was firstly described by the great Greek physician Galen of Pergamon as "ψαλιδοειδές σώμα." In particular, Galen wrote: "τὴν δὴ τοῦ ψαλιδοειδοῦς ἐκείνου σώματος χρείαν οὐκ ἄλλην τινά εἶναι τῆς τῶν ψαλίδων αὐτῶν τῶν ἐν τοῖς οἰκοδομήμασιν ὑποληπτέον," meaning "that structure (fornix) needs as supporting structure (vault or arch) for the buildings" [13]. The term "fornix" in the English nomenclature was introduced by Thomas Willis in 1664: "Fornix so called or arched Vault, as it were a string or ligament…" [19, 22].

As regards the gyri of the brain's lobes, Casserius in Figure II of the Table II of his "Tabulae Anatomicae" provided an aspect of the lateral surface of the left frontal and parietal lobes failing however to demonstrate with clarity their precise morphology. He displayed four to five sagitally directed frontal gyri instead of usually three detected gyri. The oblique course of the inferiormost gyri presumably leads to the formation of the known "central sulcus of Rolando." With respect to the parietal lobe, Casserius failed to design with accuracy its various morphological features (Fig. 6 and cover). Casserius termed the brain's gyri "spirae or anfractus," whereas Galen has named them "ἕλικες or ἕλιγμα," Zerbi "anfractus" (1502), Vesalius "involutiones or revolutions or implexuses" (1543), Piccolomini "spirae" (1586), and Willis "girae or plicae or convolutions (1664) [14].

It is considered that Casserius discovered and designed the arachnoidal granulations in his work "Iulii Casseri Placentini Tabulae Anatomicae…" that printed in Venice in 1627 (Fig. 7) many years before Antonio Pacchioni (1665–1726) [21, 26]. Pacchioni in his work entitled "Dissertatio Epistolaris de Glandulis Conglobatis Durae Meningis Humanae, indeque Ortis Lymphatics ad Piam Meningem productis" that was published in Rome in 1705 and while investigating the superior sagittal sinus noticed on both sides of the sinus the presence of small globular bodies surrounding by a separate capsule and naming them "glandulae conglobatae." He had seen many filaments emerging from these "glandulae" incorporating into the pia, considering them as lymphatic vessels. Thus, Pacchioni considered that these

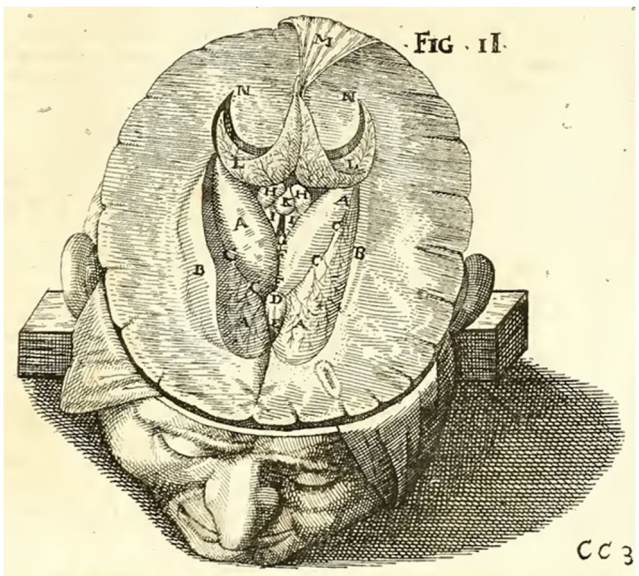
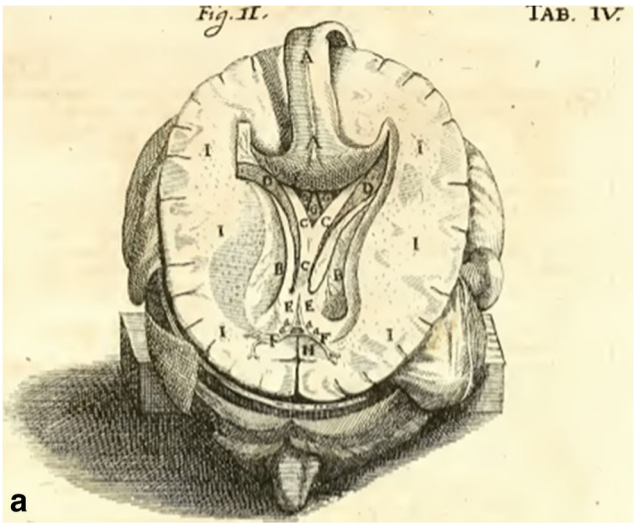


Fig. 4 In Figure II of the Table V of Casserius' work "Tabulae Anatomicae," the interventricular foramen as well the thalamostriate sulcus are well demonstrated



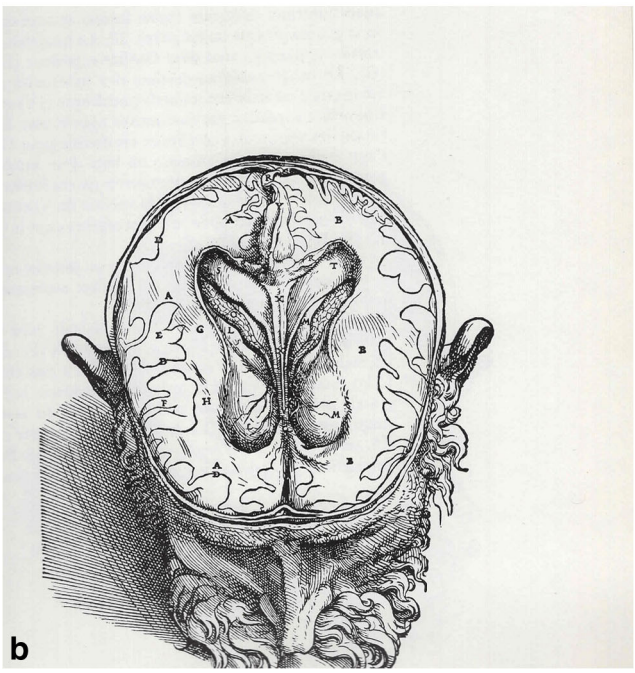


Fig. 5 **a** In Figure II of the Table IV of Casserius' work "Tabulae Anatomicae," the corpus and crus of the fornix are well shown. **b** In Table 68 of the "Fabrica" of Vesalius (1543), the fornix is shown at the midline of the brain

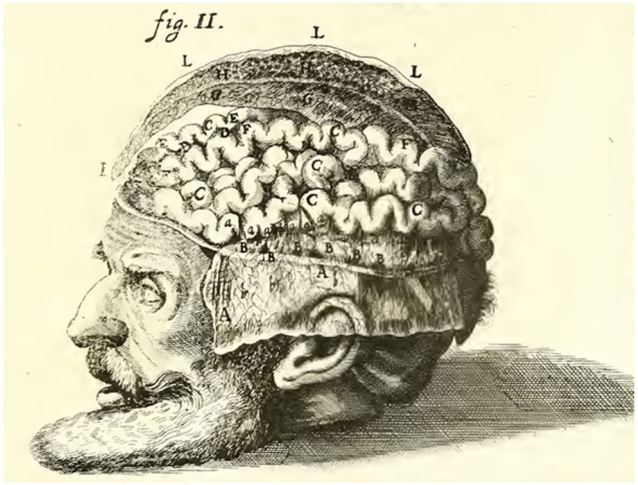


Fig. 6 and cover In Figure II of Table II of Casserius' work "Tabulae Anatomicae," the morphology of the lateral aspect of the left frontal and parietal lobes is designed

"glandulae" produce lymph in order to lubricate the movements between meninges and brain [3, 20].

It has been said that Casserius discovered the habenular trigone [21], an anatomical structure that officially is known that has not been described until 1840 [27]. Moreover, it has been stated that Casserius discovered the inferior vermis [21], an anatomical element that was previously described and designed clearly by Vesalius [14].

Casserius provided a precise demonstration of the thalamostriates sulci in Tables III and IV but especially in Figure II of Table V of his Libre X of his "Tabulae Anatomicae" with the corresponding figure legend, written presumably by Daniel Bucretius (Fig. 4). Casserius named those sulci "rimae siue canals leuter in substantia eorundem

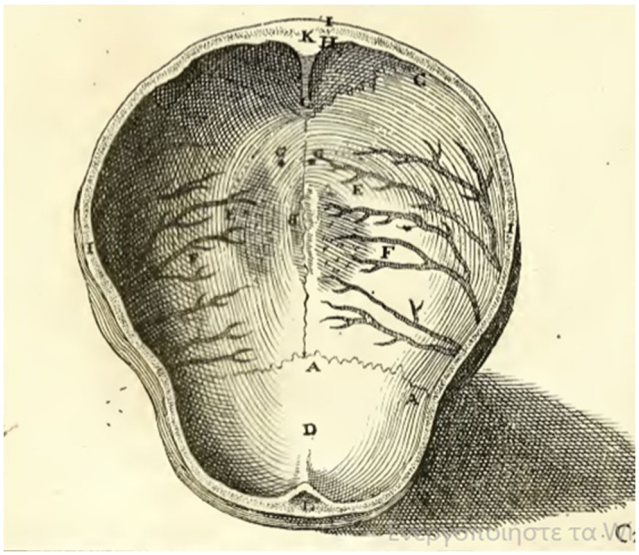


Fig. 7 The granular foveola of the intracranial aspect of the parietal bones, where the arachnoidal granulations are rested, are demonstrated in Table IV of Casserius' work "Tabulae Anatomicae"

venticulorum exsculpti" which means "slits or channels which people actually call ventricular grooves."

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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