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Fascia and spaces on the neck: myths and reality

Fascije i prostori vrata: mit i stvarnost

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Abstract. The ongoing discussion concerning the interpretation of existing or not existing fasciae on the neck needs a clarification and a valid terminology. Based on the dissection experience of the last four decades and therefore of about 1000 cadavers, we investigated the fascias and spaces on the neck and compared it to the existing internationally used terminology and interpretations of textbooks and publications. All findings were documented by photography and the dissections performed on cadavers embalmed with Thiel's method. Neglected fascias, such as the intercarotid fascia located between both carotid sheaths and passing behind the viscera or the Fascia cervicalis media as a fascia between the two omohyoid muscles, were dissected on each cadaver. The "Danger space" therefore was limited by fibrous walls on four sides at level of the carotid triangle. Ventrally there was the intercarotid fascia, laterally the alar fascia, and dorsally the prevertebral fascia. The intercarotid fascia is a clear fibrous wall between the Danger Space and the ventrally located retropharyngeal space. Latter space has a continuation to the pretracheal space which is ventrally limited by the middle cervical fascia. The existence of an intercarotid fascia is crucial for a correct interpretation of any bleeding or inflammation processes, because it changes the topography of the existing spaces such as the retropharyngeal or "Danger space" as well. As a consequence, the existing terminology should be discussed and needs to be adapted.

Key words: anatomy; fascias; neck; spaces; terminology

Sažetak. Interpretacija i nomenklatura fascija vrata razlikuju se u pojedinih autora. S obzirom na to neophodno je ovu temu detaljnije razjasniti i usuglasiti terminologiju. Na temelju našeg višegodišnjeg iskustva u seciranju na 1000 kadavera, istražili smo fascije i prostore vrata i usporedili naše nalaze s postojećom međunarodnom terminologijom i opisima u udžbenicima i publikacijama. Svi nalazi su dokumentirani fotografijama, a preparati su pripremljeni metodom Thiel. Na svakom preparatu prikazane su interkarotidna fascija – razapeta između lijeve i desne vagine karotike, smještena iza visceralnih organa vrata – te fascija cervicalis medija koja je razapeta između dvaju omohoidnih mišića. „Opasan prostor“ u razini karotičnog trokuta omeđen je vezivnim pregradama s četiri strane. Sprijeda se nalazi interkarotidna fascija, lateralno alarna fascija i straga prevertebralna fascija. Interkarotidna fascija je zid koji odvaja „opasan prostor“ od retrofaringealnog prostora. Retrofaringealni prostor povezan je s pretrachealnim prostorom koji s prednje strane omeđuje srednja cervikalna fascija. Poznavanje interkarotidne fascije ključno je za pravilno razumijevanje krvarenja i upalnih procesa, budući da ona mijenja topografske odnose retrofaringealnog prostora i „opasnog prostora“. Sukladno tome, postojeća terminologija treba se prilagoditi.

Ključne riječi: anatomija; fascije; prostori; terminologija; vrat

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INTRODUCTION

The interpretation of fascias and spaces of the neck is a still ongoing debate not only on the anatomical platform concerning topography and terminology but includes a clinical background by many different fields such as anaesthesiology, ENT surgeons (ear, nose, throat) dentists, plastic surgery and traumatology. Surgical procedures or anaesthetic block techniques have to be aware of the topographical anatomy of the fascias themselves as well as of the spaces. Therefore it is crucial, that anatomists provide a clear and, what is more, correct description of fascias and spaces on the neck. In this manuscript, I would like to compare two different interpretation and terminologies of the fascias. One is based on the official "Terminologia Anatomica"¹, the other on the terminology mainly used in Central Europe, which will be named as the "Graz version" in the entire manuscript. Before starting with the interpretation, the two terminologies should be compared to each other (Table 1).

The shown table clearly indicates, that depending on literature and region, different classifications exist. This manuscript follows the interpretation of the "Graz version" entirely. The classification used can be found in the textbook of topographical anatomy, written by Hafferl/Thiel². It follows not only the description but strengthens the argumentation of correct interpretation by photos of proof based on dissection and experience of the entire staff members of the department of anatomy, consisting of four professors and 3 assistants .

The author of this manuscript himself can refer on experience of dissection of about 1000 cadavers. As a consequence, the interpretation presented in this manuscript is based on experience of more than 40 years and thousands of cadavers excluding the experience which moved into the textbook written by Hafferl/Thiel. In addition, one should notice, that there is a special embalming fluid used in Graz. The worldwide well known Thiel's method is a preservation method which gives the cadavers lifelike conditions, tissue behaviour, colours and

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flexibility comparable to the living³. Therefore, cadavers preserved with Thiel's method had already been used for investigations on the anaesthesiological platform, were spaces of the neck were injected to assess the spread of the injectate⁴⁻⁷.

THE GRAZ VERSION

The "Graz version" of fascias

Before comparing the "Graz version" to other classifications and descriptions, this version should be described first. All different layers are listed and described from superficial to deep layers. Spaces are described after the layers. In addi-

Table 1. Comparison of the two basic terminologies: please be aware that not all terms are found in the two classifications.

Graz Version	International Terminology
Skin	Skin
Panniculus adiposus (subcutaneous fat pad)	Fascia cervicalissuperficialis
Platysma	Superficial layer of the deep cervical fascia
Fascia cervicalissuperficialis (superficial cervical fascia): FCS	-
Fascia cervicalis media (middle cervical fascia): FCM	Middle layer of deep cervical fascia; pretracheal layer
Fascia buccopharyngea: visceral fascia; buccopharyngeal fascia	Vagina carotica
Vagina carotica	-
Fascia cervicalisprofunda	-
Lamina superficialis: Fascia intercarotica (FI; superficial layer of deep cervical fascia)	Alar fascia*
Lamina profunda:Fasciaprervertebralis	Deep layer of deep cervical fascia
Fascia alaris	-

* The asterisk marks the fascias described by Grodinsky and Holyoke.

tion, one should notice that the author honours the Latin terminology and keeps these terms. The English terminology will be discussed later on.

Panniculus adiposus (subcutaneous fat pad):

The fat pad is in between the skin and the platysma. Depending on the body mass index and sex, the subcutaneous tissue layer might contain quite a thick layer. This layer can be removed from the platysma underneath easily without removing the fascia of the platysma because there is soft connective tissue located in between. The thickness of the fat pad regularly is in the submental region well developed (Figure 1).

Platysma: This muscle is a partially well developed and sometimes very, very thin muscle layer. Fibres extend all along the neck and continue cranially in the parotideomasseteric region as well as caudally to the clavicle. In cases where the muscle layer is thin, venous and nervous structures already can be identified underneath this layer. The fascia of the muscle can be removed easily as well. Elevating the muscle, there is another layer of soft connective tissue containing different nerves and vessels. Concerning nerves, we have to list the sensitive nerves of the cervical plexus, known as the nerves of the Punctum ERBI. These are: great auricular nerve, transverse cervical nerve, lesser occipital nerve and with a respectable distance more caudally the supraclavicular nerves. Additionally there are the external jugular vein crossing the sternocleidomastoid dorsally and laterally to reach the posterior margin of latter muscle and the anterior jugular vein at the anterior border of the sternocleidomastoid (Figure 1).

Fascia cervicalis superficialis (FCS): This fascia is the superficial body fascia which continues either cranially into the "Fascia parotideomasseterica" or caudally into the "Fascia thoracica superficialis" which covers the greater pectoral. This fascia is a strong and especially in the ventral parts of the neck well developed tissue whereas the fascia cannot be well dissected without damage in the lateral cervical triangle (=posterior triangle) (Figures 2 and 3). Medial to the sternocleidomastoid, the FCS inserts with fibres at the ventral face of the manubrium of sternum. The above mentioned nerves of the Punctum ERBI have to

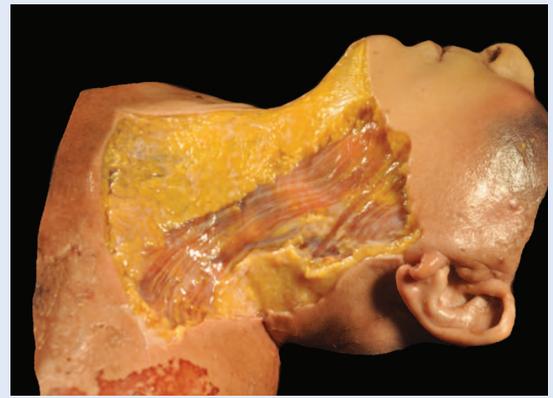


Figure 1. Dissection of the left neck region: the skin is removed and subcutaneous fat tissue still visible in the anterior regions of the neck. Dorsally the panniculus adiposus is removed and the Platysma clearly visible.



Figure 2. FCS dissection of a left neck region: please remark the fat tissue underneath the fascia in the lateral cervical triangle.

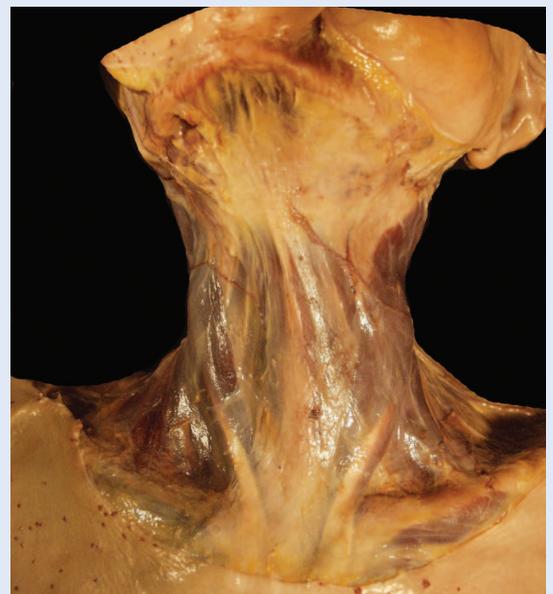


Figure 3. Ventral aspect of a dissected FCS.

perforate the fascia at different levels. However, except of the supraclavicular nerves, all other lies close to each other. The supraclavicular nerves themselves arrive in the subcutaneous layer either a by forming one or two trunks. Lower frequent is that the three nerves (medial, middle and lateral) perforate the fascia separately.

Fascia cervicalis media: this fascia covers and envelops the infrahyoid muscles also named “*Detractores laryngis*”. This fascia has a strong and aponeurotic character, mainly in the cranial and medial regions. As the fascia is limited to the lateral border of the omohyoidei, this fascia is visible in the lateral cervical triangle in the medial corner only. This is the area, where the omoclavicular triangle is formed and the external jugular vein has to pass the fascia on its way to their ending in venous confluens of PIROGOFF (Figures 4 and 5). Its caudal insertion is at the dorsal aspects of either the manubrium of sternum or the clavicle.

Fascia visceralis (buccopharyngea): This is the fascia covering the viscera of the neck, including pharynx, larynx, thyroid gland and esophagus. It is a fascia which can be removed from the muscle layers of the pharynx.

Vagina carotica: this is a strong connective tissue tunnel which surrounds three large structures of the neck: the common carotid artery, internal jugular vein and the vagus nerve. It is described, that all three have their own tunnel. We can confirm this description in the area of the common carotid artery. After the carotid bifurcation, where external and internal carotid arteries are formed, it is not that clear if the tunnels continue.

Fascia intercarotica (FI): This partially thick wall of dense regular connective tissue crosses the median plane from the left vagina carotica to the right one. On its way medially it gets a relationship to the pharynx by passing dorsally. However, this fascia might be fused with the buccopharyngeal fascia laterally or dorsally to the pharynx. Sometimes the intercarotid fascia arrives on the opposite side without and fusion to the ventrally situated visceral fascia (Figures 6, 7 and 8). On its way caudally the fascia follows the course of the carotid arteries ventrally. As a consequence, the



Figure 4. Dissection of an entire FCM between the two omohyoidei muscles: a blue probe is positioned underneath the fascia in the pretracheal space.

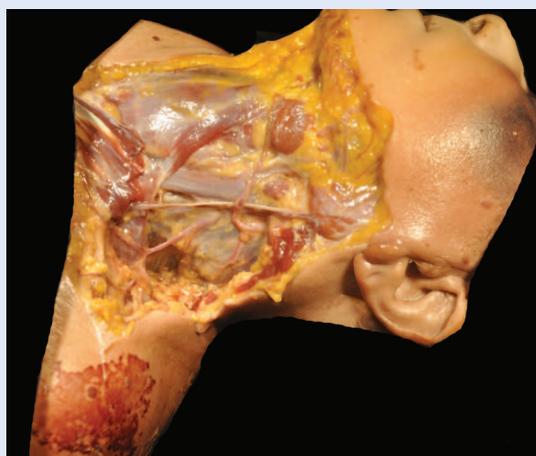


Figure 5. FCM of a left neck: The caudal part of the sternocleidomastoideus still covers the fascia.

visceral organs (trachea, esophagus) have to pass this fascia from cranial and ventral to caudal and dorsal. In addition the inferior thyroid artery and the recurrent laryngeal nerve take the opposite course to reach their final targets of blood supply or innervation.

Fascia prevertebralis (FPV): this strong connective tissue layer covers the prevertebral muscles, so longuscapitis, longuscolli and the scalene muscles as well (Figure 9). It fuses with the vertebral

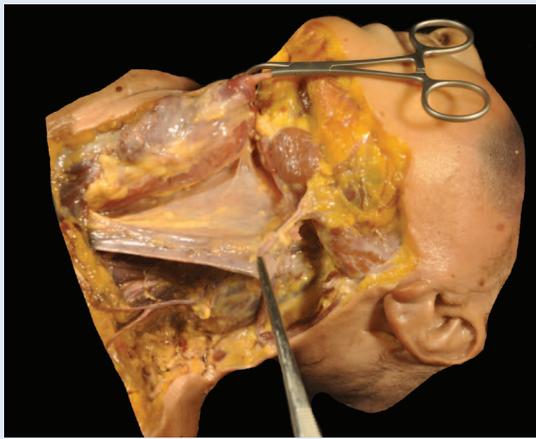


Figure 6. FI (Fascia intercarotica) of a left neck: neck viscera are moved ventrally and the vagina carotica laterally by the tweezers. The FI is clearly visible and passes behind the Pharynx.

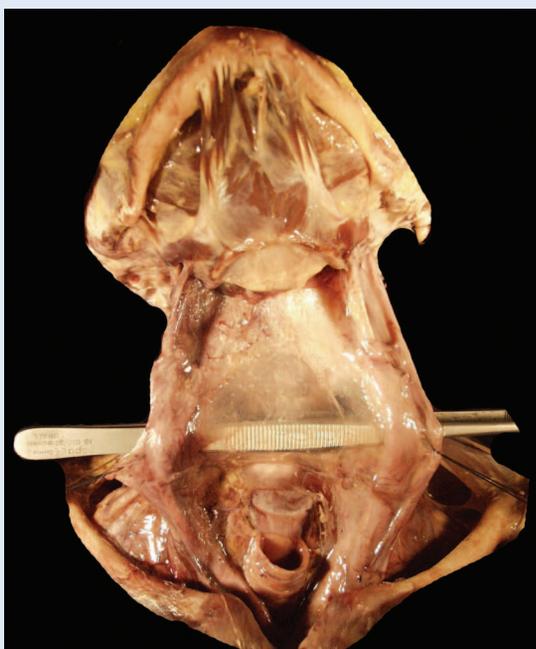


Figure 7. Ventral aspect of a dissection of an entire FI. The Tweezers is positioned behind (Danger space).

bodies in the median plane sometimes. This fascia runs laterally and lay superficially to the subclavian artery and the brachial plexus, which both arrive between the two scalene muscles in the posterior interscalene gap in the lateral cervical triangle. Caudally and laterally, the fascia elevates and inserts in the fascia of the subclavius. It continues dorsally and mantles the dorsal deep muscles of the neck. In the area of the trapezius, where the superficial cervical fascia has to split for enveloping the trapezius, it fuses with this fascia. The fascia envelops two important nerve structures: first the sympathetic trunk and second the phrenic nerve. The sympathetic trunk might be covered by a thin layer of connective tissue, which is like a double layer of the FPV, ventrally which explains the fact that the trunk can be elevated gently from the FPV in most of the cases. Another important fact is, that the FPV splits at level of the carotid tubercle of Chassaignac (corresponds to the anterior tubercle of the transverse process of C6). The fascia follows the inferior oblique part of the longus colli medially and the anterior scalene muscle laterally which leaves no posterior wall between these two muscles. As a consequence the scalenovertebral triangle, which is located between these two muscles continues dorsally and has a connection to the prevertebral space and even the intervertebral foramen. This is a very important topography because the intervertebral foramen is the connection of the prevertebral space and the epidural space.

Fascia alaris (FA): this is a thick wall of dense connective tissue which extends between the vagina carotica and the FPV in a sagittal plane. Its extension is cranially to the skull base, caudally it might have a limitation at level C6 or C7. The fascia is

Table 2. Comparison of the two basic terminologies: please be aware that not all terms are found in the two classifications.

Graz Version	International Terminology
Spatium (interaponeuroticum) suprasternale	Suprasternal space
Spatiumomoclaviculare (interaponeuroticumsupraclaviculare)	Pretracheal space
Spatiumpretracheale	Retropharyngeal space
Spatiumretropharyngeum	Retrovisceral space*
Spatium prevertebraleinterfasciale (Dangerspace)	Danger space*
Spatiumprevertebrale	Prevertebral space

*The asterisk marks the spaces which are determined by Grodinsky and Holyoke only.

also a guide for the inferior root of the ansa cervicalis (Figure 10).

The "Graz Version" of spaces on the neck

Due to the existing terminology of the fascias different spaces are formed. According to the descriptions, some of these spaces are strictly limited by fascias which form strong borders. Others might be connected. These topographical details are very important concerning inflammation processes or bleedings. As a consequence the spaces are listed in the same order as the fascias above.

Spatium interaponeuroticum suprasternale: This space is located medial to the sternocleidomastoid between the FCS and FCM and contains fat tissue and the connection in between the two anterior jugular veins which is named the jugular venous arch.

Spatium interaponeuroticum supraclaviculare: the space can be seen as the extension of the suprasternal space lateral to the sternocleidomastoid. Again, this small space is filled with fat tissue but also let the external jugular vein pass on its way to their confluence. Therefore this vein has to pierce the FCS first and secondly the FCM.

Spatium pretracheale: The space can be found behind the FCM. The wideness of this space changes from cranial to caudal direction. It contains the visceral organs such as larynx, pharynx, esophagus, trachea and the thyroid gland. The pretracheal space impresses as a small gap cranially but explores a huge extension the more one arrives caudally. Especially caudal to the thyroid gland, this space contains loose connective tissue, fat tissue and the draining of the thyroid gland, known as the unpaired thyroid plexus. Following the plexus caudally, the space continues in the anterior superior mediastinum (Figure 11). Caudal to the thyroid gland, the posterior wall, which is the intercarotid fascia gets ventrally to let the viscera pass this fascia. As a consequence, the viscera have to leave the pretracheal space and to reach the posteriorly located danger space.

Spatium retropharyngeum (Spatiumretroviscerale, RVS): This is the dorsal and lateral extension of the pretracheal space. It contains both lobes of the thyroid gland and certainly the structures to the larynx. Dorsally this space is limited by the

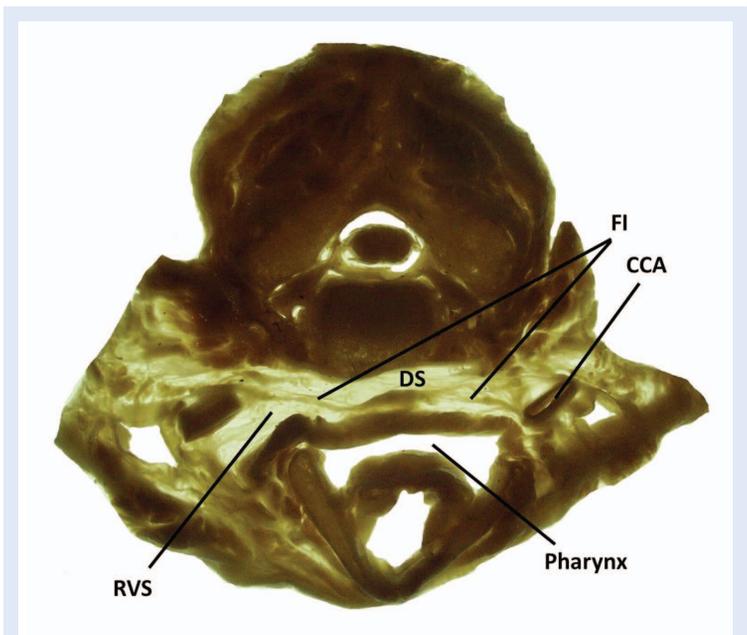


Figure 8. Cross section of a neck. The FI is easily identifiable and connects the two common carotid arteries (CCA). Ventrally there is the retrovisceral space (RVS) and dorsally the Dangers space (DS).

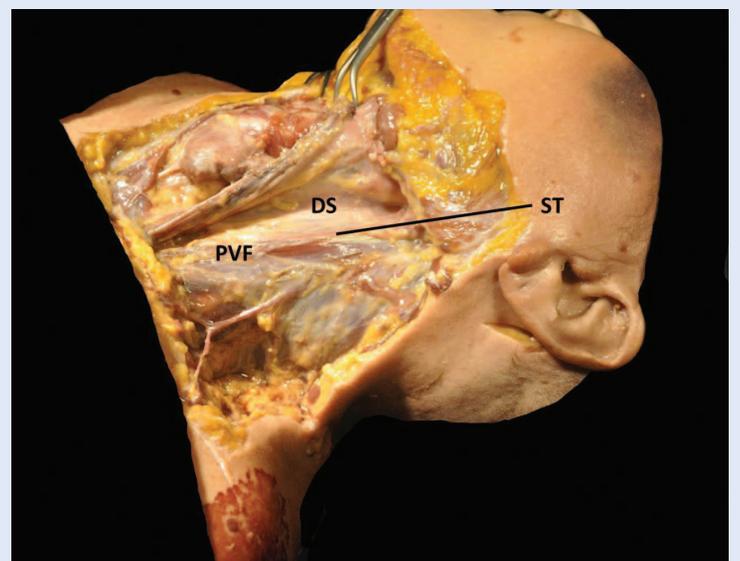


Figure 9. The vagina cartica is moved ventrally, and the prevertebral fascia (PVF) is exposed and partially opened. The sympathetic trunk (ST) is visible.

FI. The great variability of this space depends on the fusion of the buccopharyngeal fascia with the FI. Do these fascias fuse at the lateral edge of the pharynx, there exists no real retropharyngeal space. In case of a fusion in the median plane, this space is filled with loose connective tissue (Figure 8).



Figure 10. The fascia alaris (FA) is exposed and partially incised, therefore the Danger space opened. The inferior root of the ansa cervicalis is visible which is running along the AF to reach the vagina carotica.

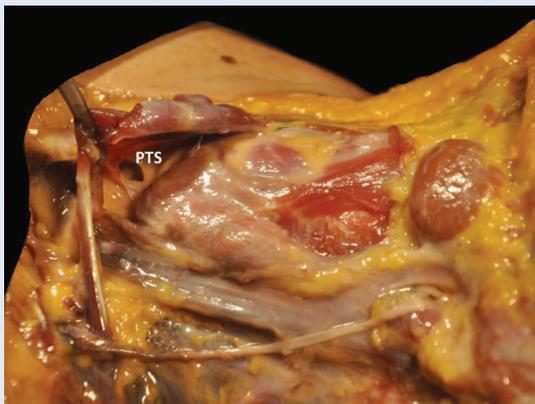


Figure 11. The infrahyoid muscles are elevated and the pretracheal space (PTS) exposed.

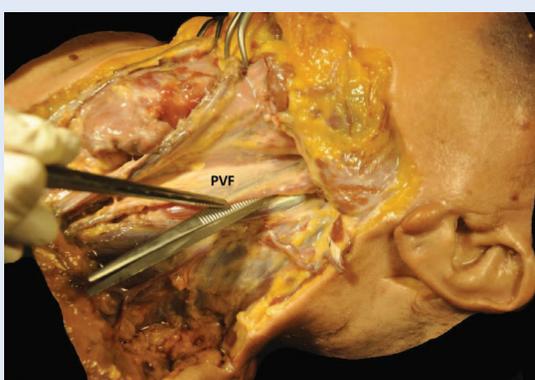


Figure 12. The prevertebral fascia (PVF) is elevated and the tweezer is inserted in the prevertebral space. The sympathetic trunk is also elevated as it is surrounded by the PVF.

Spatium prevertebrale interfasciale (Danger space): the space impresses as a small gap in its cranial extension. The space is limited ventrally by the FI, dorsally by the FPV and laterally by the FA. Cranially it extends to the skull base, caudally it continues in the posterior mediastinum. As the FI runs ventrally in the caudal part of the neck, it is obvious that the Danger Space becomes a wide and large space, which is important for any inflammation or for example spreads of local anaesthetics for pain therapy or regional anaesthesia. Contents of this space is the sympathetic trunk and in the caudal part trachea and esophagus. Other important structures are two structures running cranially from the Danger Space into the pretracheal space: the inferior thyroid artery and the recurrent laryngeal nerve (Figure 8 and 9).

Spatium prevertebrale: this space is filled with the anterior and lateral prevertebral muscles. As the longus colli has its most caudal extension to the level of Th4, the space is limited to this level. Laterally to the anterior scalene muscle, the prevertebral space continues caudally underneath the clavicle. In the deltoideopectoral region, the space is limited ventrally by the clavipectoral fascia and still continues to the axillary fossa where the space is covered by the deep axillary fascia. Contents of the space are the different parts of the brachial plexus as well as the axillary artery to reach the upper limb (Figure 12).

DISCUSSION

Interpretation of the fascias and spaces of the neck are very important for clinicians of different fields. ENT surgeons have to provide detailed topography because of surgical procedure such as neck dissections or surgical treatment of retropharyngeal abscesses. Anaesthetists do need the structures for injecting local anaesthetics into the correct spaces to get efficient nerve blocks⁸⁻¹⁰. Traumatologists should know about some fascias to avoid damage of nerve structures during some approaches to the cervical spine¹¹. As a consequence anatomists are not the only specialist who is interested in the anatomy and terminology of the fascias and spaces of the neck. Anyway, all of the different field should ideally follow and

accept one common terminology. Exactly this is the problem. Many authors do follow the international terminology, which is listed in table 1. Regarding this classification more precisely, the problem becomes obvious. The international terminology does not list two important fascias: FCM and Fascia intercarotica. We would like to discuss the problem on one of the fascias only because discussing all of the fascias would exceed the length of the manuscript. Both of the fascias listed are important concerning the spaces which they are the borders of. Let us take a closer look on the intercarotid fascia now. Neglecting or ignoring the existence of this fascia means that there should be a direct connection of the pretracheal space to the Danger space via the retropharyngeal space. Regarding the dissections shown in this manuscript, the fascia exists. It is no ghost, fata morgana or virtual structure. It can be dissected easily in each cadaver and is a frontally plane of dense connective tissue. Grodinsky and Holyoke describe a complete layer connecting the carotid sheath and which lies between the visceral and prevertebral layer and named it alar fascia¹². Interestingly this is in contrast to the description of Charpy who found a sagittal septum with the term “ala fascia”¹³. Regarding the alar fascia of Grodinsky and Holyoke, this fascia is similar to our FI. The described fascia of Charpy would correspond to our “Fascia alaris”. Obviously there is a little bit of confusion about the terms “alar fascia” and “ala fascia”. So, one should take a look on amount of investigated materials. Grodinsky and Holyoke base their information on about 75 cadavers and another 8 cadavers were injectate was placed into the different spaces. Unfortunately, there is no further information how the cadavers were preserved or which injectate had been taken.

What about more recent books. Gray’s Anatomy strictly follows the international terminology, so ignore a FI as well as the FCM¹⁴. So it is clear that their description concerning the spaces, especially Danger Space and retropharyngeal space, is confusing concerning limitations and connections. In contrast to that, Hafferl/Thiel list the FI². We have to note that both textbooks point out to the manuscript of Grodinsky and Holyoke but changed the term from “alar fascia” to FI. This

might be because they combined the very precise and profound manuscript of Grodinsky and Holyoke with the description of Charpy. Certainly two fascias with the same term would cause more confusion. Therefore the creation of the FI might have taken place. Other atlases for example ignore the FI, to^{15,16}.

Recent publications came from a research group of New Zealand. The information and interpretation about the fascias of Guidera¹⁷ is based on the comparison of different publications, relevant

“Danger Space” becomes a wide and large space, which is important for any inflammation or for example spreads of local anaesthetics for pain therapy or regional anaesthesia.

texts from books of Radiology, Head and Neck Surgery, Plastic Surgery, General Surgery and Otorhinolaryngology of the Australasian reading lists for specialist training schemes were reviewed. As in this area the spoken language is English, the authors do not review any other textbook written in any other language. Therefore, one serious problem arises: the authors fail to include German or French literature with much important information about the crucial existence of the FI. It is clear, that the authors got some problems in interpreting the “alar fascia” of Grodinsky and Holyoke. They state that this fascia either correspond to the prevertebral layer or is an inconsistently mentioned fascia. Anyway, two years later the same group published a manuscript where the author state that the alar fascia is a division of the deep layer of the deep cervical fascia spanning between the transverse processes and the carotid sheath. Well, one might be confused because in this case the alar fascia would be oriented in the sagittal plane and therefore corresponding to the fascia mentioned by Charpy and not by Grodinsky and Holyoke. We can reassure the reader: obviously Guidera¹⁸ misinterpreted the manuscript or mixed the definitions up. In addition, we have to take the Method into consideration how this research group collected their information and data. In the manuscript of 2014.¹⁸, they stated having conducted a

“Medline” research and the inserted illustration created by the anatomy of E 12 plastinated slices of one cadaver and from MRI images. Concluding, this research group published two manuscript without providing own collected data on one single dissected cadaver. To provide illustration based on one plastinated specimen seems to be not a very valid and proper analysis of this complex topic. Additionally such a method is questionable whether the interpretation does include all important and relevant information. As the authors fail, although performing a very exhausted literature research for the second manuscript, to include German textbooks and misinterpreted the descriptions by Charpy and Grodinsky, crucial information is lacking and therefore the review with most of the conclusion doubtful.

Danger space or retropharyngeal space: Grodinsky and Holyoke do differ between these two spaces because they list the alar fascia (FI) as the frontally oriented plane in between these spaces. Guidera et al followed this description in their publication 2012¹⁸. Two years later, the same author abandon the term Danger space due to the fact that the alar fascia cannot be visualized by current imaging. As a consequence it is better to render the term “Danger space” obsolete and to see the two compartments as one single. Such an interpretation does not match with our anatomical findings at all. What is more, radiologists decide narrow minded. What is not seen in their visualizations cannot be there. Such a statement is more than questionable because as seen and presented above, we are talking about a well-developed layer of dense connective tissue.

Where do such interesting descriptions come from? Well, mostly that the data collections might be performed, as above seen, by literature research of already confusing or wrong interpretations or second by investigation of not valid amounts of dissections. Again, Guidera et al based their “findings” by interpreting slices of one cadaver. Everybody will agree that this is not a very solid amount of investigated cadaveric specimens. In addition, most of the manuscripts provide no exact material. Even the most corresponding interpretation to the “Graz version”,

the paper of Grodinsky and Holyoke give no information about the embalming method. Due to the fact, that the most common method is the classical technique using formaldehyde, we have to face the result of such an embalming technique. Formaldehyde creates very hard cadavers, not flexible with no contrasts and a tissue behaviour which is far away from the living. The embalming method used in Graz and the base for all data and interpretations presented in this manuscript is Thiel’s method³. This technique is worldwide known as the most accepted preservation method which offers tissue behaviour close to the living¹⁹⁻²². As a consequence we can assure that all presented dissections are no artefacts, created by artificial dissection but dissections following the dense connective tissue layers and in case of opening of a space smooth dissection by tweezers. Concluding, our information and knowledge is based on direct proofed evidence by dissection documented by photography. Even more, the descriptions match with many clinical descriptions of spread of local anaesthetics and consecutive side effects or complications²². Nevertheless there are still some unanswered questions: the craniocaudal extension of the carotid sheath or FA. How often does the retropharyngeal space really exist? Many more can be listed which can be answered by injections and dissections on special preserved or fresh cadavers only and compared with the clinical and radiological findings. It will be a task not only for anatomist but also clinicians to work together and to create a common language and valid terminology for everybody in the world.

Conflicts of interest statement: The author report no conflicts of interest.

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