Annals of Anatomy 192 (2010) 17–22

Contents lists available at ScienceDirect

Annals of Anatomy

journal homepage: www.elsevier.de/aanat

RESEARCH ARTICLE

The anatomy of the sympathetic pathway through the pterygopalatine fossa in humans

M.C. Rusu [a,*,1], F. Pop [b]

[a] Discipline of Anatomy and Embryology, Faculty of Dental Medicine, University of Medicine and Pharmacy "Carol Davila" 8, Bd. Eroilor Sanitari, RO-76241 Bucharest, Romania
[b] Chair of Pathology, Faculty of Medicine, University of Medicine and Pharmacy "Carol Davila", Bucharest, Romania

ARTICLE INFO

Article history:
Received 14 November 2008
Received in revised form
27 September 2009
Accepted 13 October 2009

Keywords:
Orofacial pain
Facial neuralgia
Headache
Maxillary artery
Superior cervical ganglion
Human pterygopalatine ganglion

SUMMARY

Generally, sympathetic distribution in the pterygopalatine fossa (PPF) is considered to be via the pterygopalatine ganglion (PPG) sympathetic root and branches. We hypothesized that there may be a dual sympathetic path within the PPF, through the vidian nerve and the PPG and through the periarterial plexuses. We dissected 10 human adult cadavers, fixed and unfixed; we applied antibodies for tyrosine hydroxylase (TH) to 5 human adult samples of PPF contents dissected from cadavers at autopsy. We identified TH(+) nerves and fibers distributed through the neuronal clusters of the PPG and also bundles extrinsic to these clusters, distributed along the maxillary artery. Also, TH(+) reactions were identified at the level of the neuronal capsules of the PPG. All the arteries within the PPF presented TH(+) fibers, periadventitial and intramural—the periarterial plexuses were also identified during dissections, a major one being that along the descending palatine artery, distinctive to the greater palatine nerve. Thus, concerning the sympathetic entry to the PPF, this one seems to use both the path of the external carotid artery (via the maxillary artery plexus) and the path of the internal carotid artery, via the vidian nerve supplying the PPG and reinforcing the maxillary artery plexus. The sympathetic exit of the PPF uses the neural scaffolding of the PPG branches and also the arterial scaffolding. The complex trigeminal–autonomic, anatomic content of the PPF may be involved in several distinctive facial algias and thus the pain may be relieved by routine approaches to the PPF, based on updated anatomical knowledge and a correct diagnostic.

Introduction

Traditional resources of anatomy generally take into account the parasympathetic scaffold of the pterygopalatine ganglion (PPG) function (Gray, 1918). Being supplied by sympathetic postganglionic fibers from the superior cervical ganglion (SCG) it is either considered that these fibers will distribute via some or all of the PPG branches (Kahle and Frotscher, 2003, Pollock et al., 1997, Galan Cortes et al., 1986, Berkovitz et al., 2003) or an exact distribution distal to the pterygopalatine fossa (PPF) is not provided in the descriptions (Gray, 1918). Also sympathetic fibers coming from the PPF may supply the lacrimal gland using the postganglionic parasympathetic pathway (Berkovitz et al., 2003).

With the exception of sudomotor cells, the sympathetic neurons stain positively with antibodies to tyrosine hydroxylase (TH; Tubbs et al., 2008).

Sluder's neuralgia, cluster headache and sympathetic neuralgia in the face are likely to be of vascular origin from the branches of the external carotid artery (Kaeser, 1989) but anatomists have not paid much attention to this or to the study of the anatomical sympathetic scaffold underlying, at the level of the PPF, these mechanisms. So, the research question for our study was "What is the morphological pattern of the sympathetic pathway through the PPF?" and the hypothesis we raised was that a dual path pair, that of the vidian nerve and that of the perimaxillary artery plexus, is involved in conveying sympathetic impulses through the PPF. For this, we investigated the microscopic anatomy of the PPF structures, using antibodies to tyrosine hydroxylase. There are very few indexed references dealing with structural aspects of the human PPG (Rusu et al., 2009) and seemingly none of these deals with the sympathetic course through the PPF—this was the rationale for us to perform our research on human samples of PPF.

Abbreviations: PPG, pterygopalatine ganglion; PPF, pterygopalatine fossa; SCG, superior cervical ganglion; TH, tyrosine hydroxylase; SIF, small intensely fluorescent; NPY, neuropeptide Y; DBH, dopamine-beta-hydroxylase; VIP, vasoactive intestinal polypeptide; CGRP, calcitonin gene-related peptide; ICA, internal carotid artery; ECA, external carotid artery

* Corresponding author. Tel.: +40 722363705.
E-mail address: anatomon@gmail.com (M.C. Rusu).
[1] Home address: Str. Anastasie Panu 1, Bloc A2, Scara 2, Etaj 1, Apart. 32, Sector 3, RO-031161 Bucharest, Romania.

0940-9602/$ - see front matter © 2009 Elsevier GmbH. All rights reserved.
doi:10.1016/j.aanat.2009.10.003

Materials and methods

For the macroscopic study we dissected and microdissected 10 human adult cadavers (Caucasian), sex ratio (males:females) 3:2 and a mean age of 54. All the cadavers were available in the department of anatomy of the first author institution and were used according to the institutional and national available ethical legislative framework. From those cadavers, 5 were approached after fixation (by a method based on a salted formalin and phenol formula) while the remaining were prosected specimens that were approached prior to their fixation in the respective department (for details see also McHanwell et al., 2008).

The approaches by dissection were: (a) the superior approach, via the middle cranial fossa floor and the sphenoidal sinus, in 5 cadavers and (b) the combined lateral and transantral approach, via the infratemporal fossa and the opened maxillary sinus, in 5 other cadavers. Prior to the superior opening of the PPF: (i) the trigeminal nerve, ganglion and branches were dissected and the maxillary nerve was followed to the foramen rotundum; (ii) the cavernous sinus was dissected, exposing the internal carotid artery (ICA) and the nerves; (iii) the hypophysis was removed and the sphenoidal sinus superior wall was removed to open the sinus; (iv) the greater petrosal nerve was identified on the petrous part of the temporal bone and dissected to the entrance in the vidian canal (proximal to the canal the greater petrosal nerve was joined by the deep petrosal nerve that was exposed during microdissection), by removing the trigeminal ganglion from the temporal bone; (v) the vidian canal was opened and the adjacent bone was removed to gain a better access (the vidian canal was either located in the sphenoidal sinus lateral recess floor or it traversed the root of the greater wing of the sphenoid bone outer to the sphenoidal sinus) and (vi) the bone between the vidian and maxillary nerves was removed and the PPF was opened, thus allowing us to identify its main components: the PPG, the maxillary and vidian nerves, and the maxillary artery.

For the combined lateral and transantral approach to the PPF, we dissected the infratemporal fossa first, accurately identifying the elements at the level of the posterior wall of the maxillary sinus and within the pterygomaxillary fissure; then we removed the zygomatic bone and drilled out the antero-lateral and posterior walls of the maxillary sinus, keeping the infraorbital nerve and artery in place. Microdissection of the PPF was then performed, exposing the PPG, maxillary nerve and artery. By drilling the pterygoid process anterior border we enlarged the access and we could also identify the endpart of the vidian nerve, which was retrogradely dissected by drilling the root of the pterygoid process.

The dissections exposing the main components of the PPF were photographically documented and then samples of PPF en-block contents were dissected out (cutting at distance to the PPF the vidian, maxillary and greater palatine nerves) of the 5 unfixed cadavers, and photographed. The PPF samples were carefully oriented by identifying the main nerves and the segment of the maxillary artery in relation to the PPG and were paraffin embedded for histological and immunohistochemical studies. Hematoxylin–eosin stain slides were made to make an accurate histological diagnosis of each sample and to compare the cut to the photograph of the sample. Immunohistochemistry was performed using the ABC method (for details, please check http://www.ihcworld.com/_books/Dako_Handbook.pdf) by use of ready-to-use primary antibodies for tyrosine hydroxylase (TH), type IgG1, clone: 1B5, mouse monoclonal, supplier: Novocastra, catalog number: NCL-TH (for details, please check http://www.ihcworld.com/_protocols/antibody_protocols/th_novocastra.htm). Tyrosine hydroxylase is the first enzyme in catecholamine biosynthesis (Nieuwenhuys, 1985).

Results

By dissecting the PPF contents we exposed the main components including the maxillary artery, maxillary nerve and PPG and the related branches. Moreover, we exposed distinctive periarterial plexuses along the maxillary artery and its locally emerged branches, better represented along the descending palatine artery (Fig. 1).

The histological stains clearly identified the main contents of the PPF.

By applying the TH marker we obtained immunopositive reactions (+) at the levels of the PPG, PPF nerves and perivascular tissue along all the arteries within the samples.

We demonstrated relatively consistent TH(+) nerves coursing adjacent to and not through the PPG; from these nerves, catecholaminergic in nature, bundles and isolated fibers were coursing through the PPG while a large bundle approached and distributed along the maxillary artery (Fig. 2). The identified pterygopalatine periganglionic nerves appeared to be largely but not exclusively composed of varicose fibers presenting clear and granular vesicles within (Fig. 3A). Isolated nerves within the PPF also presented exclusive or partial TH(+) fibers content (Fig. 3B, C).

Clusters of pterygopalatine neurons appeared traversed by TH(+) nerves of various thicknesses and by TH(+) isolated fibers (Fig. 4A, B). A few autonomic cells adjacent to the periganglionic TH(+) nerves appeared as well TH(+) (Fig. 3).

Occasionally, TH(+) reactions were apparent at the level of the individual pterygopalatine neuron capsules formed by the satellite cells and at the level of the intrinsic dendritic plexuses of the PPG (Fig. 5).

TH(+) fibers were also identified at the level of the arteries of the PPF: the maxillary artery (Fig. 6A) and its branches (Fig. 6B);

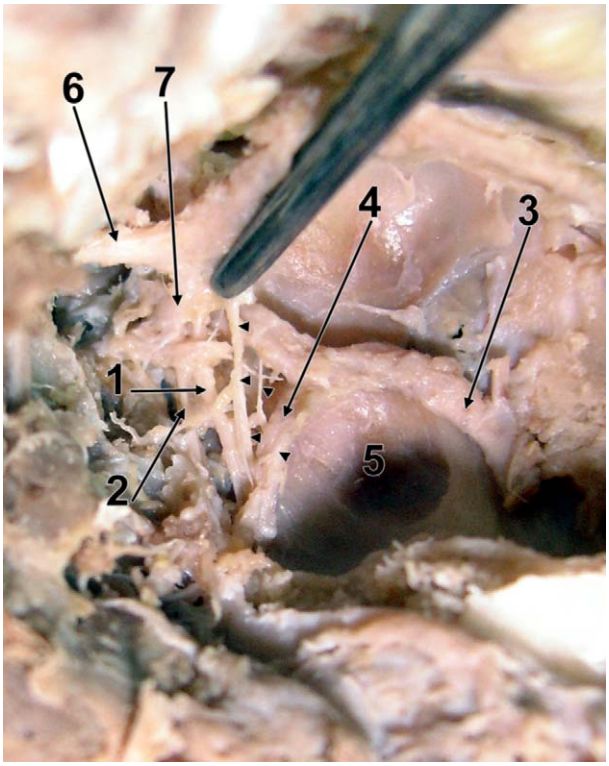

Fig. 1. Right PPF approached laterally, the maxillary sinus being opened: 1. greater palatine nerve; 2. lesser palatine nerve; 3. maxillary artery, displaced anteriorly; 4. descending palatine artery; 5. maxillary sinus; 6. maxilary nerve and 7. PPG. Distinctive periarterial nerves (arrowheads) can be identified in the PPF.