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**Introduction**

The Atlas of *cutaneous branch territories* of the human body 3rd edition deals with clinical anatomy. As the clinic gives us opportunity to observe many more axonal lesions (axonotmesis) than transections (neurotmesis), the mapped hypoesthesic territories are partial. We therefore defined the autonomous territory and the boundary markers of the largest territory of cutaneous somatosensory origin for each cutaneous nerve branch.

The 2519 patients included in this research were recruited prospectively and consecutively from July 2, 2004 to October 18, 2016. Thus, the topographic study could be carried out on 2698 aesthesiographies: maps of cutaneous hypoaeesthesic territory (\(G\)\(\equiv\) Glossary). Each anatomical plate of a cutaneous branch is the superposition of tens, and sometimes even hundreds of observations seen in clinical practice.

We also cross-referenced these 2698 aesthesiographies observed with data published in 97 anatomy books. It is reassuring to observe that the results of this third edition do not invalidate the cumulative results of the first edition. However, we have modified the presentation of some anatomical charts to improve readability.

This 3rd edition illustrates the usefulness of anatomical knowledge for clinical practice. More precisely, it seeks to demonstrate how these topographic elements make it possible to orient the clinical anamnesis, then to carry out the clinical examination.

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Largest\textsuperscript{G} territory of cutaneous origin

It would have been tempting to encircle the whole maximum skin distribution territory, but this would have been confusing, suggesting that each lesion produces a tactile sensitivity disorder covering the entire maximum territory - which is \textit{NOT} what we have observed. The purpose of this study is to instead define \textbf{five topographic elements} and to present them on an \textit{anatomical chart} for each cutaneous branch in the following way:

- The largest territory of cutaneous origin is thus the territory from which a cutaneous branch originates: it is delimited by the \textbf{four cardinal points} furthest from the centre of the autonomous territory\textsuperscript{G}. For example, of all the aesthesiographies\textsuperscript{G} of the dorsal branch of ulnar nerve, we retained the one with the most radial point (Fig. 1).

\textbf{Fig. 1:} \textit{The most radial point, on one of the axes of a cutaneous branch of the largest territory of cutaneous origin. In this example, 4 is the most radial point observed of the dorsal branch of the ulnar nerve. The locations 1, 2 and 3 observed in our series of aesthesiographies of the dorsal branch of the ulnar nerve (n = 51) are not retained because they do not correspond to the « most radial » point of the largest territory of cutaneous origin of this branch.}

A cutaneous branch cannot innervate the skin located beyond these \textbf{boundaries}. This way of limiting the largest area of cutaneous origin (Lanz von, 1935) is one of the great originalities of this work.

\textsuperscript{4} Depending on the anatomical region, it will be the most radial, ulnar, medial, lateral, anterior, posterior, superior or inferior point in relation to the anatomical position.
From symptomatology to neuropathic semiology
For this atlas to be a didactic tool, the clinician must pose the following axiom:

**Axiom :** The patient reports neuropathic pain symptoms because he has Aβ neurofibre lesions of a cutaneous branch.

It is at the cost of this intellectual effort that he will perform a clinical history to identify the neuropathic symptoms (Fig. 2).

Fig. 2: The Clinical Reasoning: Neuropathic symptoms in the partial hypoaesthetic territory of an injured skin branch. The search for the damaged cutaneous branch responsible for one or more neuropathic symptoms makes it possible to map 4A: an aesthesiography or 4b: an allodynography, then to perform the corresponding treatment technique - 6A or 6b.
We would like to emphasize the importance of the medical history and the clinical anamnesis in the study of pain. The latter is called an interrogatory because, contrary to the golden rule in clinic, the clinical anamnesis of neuropathic pain is highly directed. It is the result of a precise questioning. It is only then, that the particular time of the clinical anamnesis - when the patient remembers the painful symptoms -, will become a two-part narrative.

In order to state the hypothesis of the injured cutaneous branch by using this atlas, it is necessary to recall the following clinical anatomy knowledge:

1. The localization of the burning sensations, or even of heat, are circumscribed in the hypoaesthetic territory (Fig. 3);

![Fig. 3: Positive aesthesiography at 0.7 gram (Semmes-Weinstein monofilament # 3.84) of the lateral sural cutaneous nerve of a patient, performed on 9/4/2009 on the lateral side of the right ankle. The aesthesiography circumscribes the hypoaesthetic territory of the skin portion where this aesthesiometer is not detected.](image)

2. The electrical character of the pain radiates towards the periphery to the most distal point of the largest territory of cutaneous origin, or radiates afferently from this point.

This constant search for the link between such neuropathic symptoms and the anatomical topography is the daily work of the somatosensory therapists of pain. These qualifiers - neuropathic symptoms - are listed in the different versions of the *McGill Pain Questionnaire*: burning/boiling sensation, radiating, tingling, numb, tender, etc.

**From skin to brain**

The second great originality of this work is to have considered the organization of our research in a centripetal manner. As the somatosensory nervous system is afferent (from latin *afferre*: bring from the periphery to the centre), we have organized this atlas from the skin towards the brain. In this centripetal design, the superficial branch of radial nerve, for example, joins the radial nerve at the forearm - and does NOT leave it - which is contrary to the usual conceptualization of muscular anatomy.

The original nerve bundles are grouped together to form nerves, which are cables whose size is growing as they get closer to the central nervous system. They carry, in regard to a territory, a sum of information whose extent is directly proportional to the number of fibers contained in the nerve. However, painful disorders of skin sensitivity most often come from lesions where only a minority of nerve fibers are injured.
Traditional anatomy, that is centrifugal, has described in detail the different branches of nerves regularly visible. However, it could not describe the precise content of each of these branches, nor the exact topography of its territory of origin. This is precisely what the present atlas undertakes: it analyses the topography of the origin of the transmitted sensations for each nervous branch. It is no longer a question of dissections but of reconstructions going up from the skin to the nerve.

With this teaching tool, the practitioner, therapist or physician, can examine a subject and exclude, or not, the existence of axonal lesions within a given nerve branch. Anatomy evolves. Providing new perspectives, both practical and functional, it always supplies medicine and clinicians with valuable and unexpected information.

Patients and methods

Patients
The 2519 patients included in this research were recruited prospectively and consecutively from July 2, 2004 to October 18, 2016. They were suffering from chronic neuropathic pain referred to the Somatosensory Rehabilitation Centre. In order to study a group that is as homogeneous as possible, we restricted this topographical research to patients whose skin was accessible: they did not show hypersensitivity to touch, that is, they did not present mechanical allodynia.

The inclusion criteria is:
– a diagnosis of axonal lesions (n = 4346).

The exclusion criteria is:
– a positive allodynography (n = 1648).

It should be noted that patients who had previously a positive alldynography (exclusion criteria) at the first assessment session, and who subsequently presented a positive secondary aesthesiography, were excluded. If the presence of this underlying hypoesthesia is no longer to be proved, the boundary of these secondary aesthesiographies remains unclear. Indeed, if some receptive fields detect the aesthesiometer, some other neighboring receptor fields perceive a sensation that is still unpleasant to the touch and no longer painful. This other physiological state of the skin can then generate false positives, in other words, an aberrant clinical examination.

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This prospective research is based on 2698 aesthesiographies, first step of the diagnosis of axonal lesions - distributed among each cutaneous department of the human body as follows:

1. Trigeminal department \( n = 85 \)
2. Occipital department \( n = 61 \)
3. Cervical department \( n = 36 \)
4. Brachial department \( n = 596 \)
5. Thoraco-intercostal department \( n = 137 \)
6. Lombo-abdominal department \( n = 84 \)
7. Lombo-femoral department \( n = 120 \)
8. Femoral department \( n = 300 \)
9. Ischiatic department \( n = 1155 \)
10. Sacral department \( n = 124 \)

Methods

The aesthesiography (Létiévant 1869, 1875, Spicher & Kohut 2001, Spicher 2003, Spicher & Quintal 2013) is the mapping of a hypoesthetic skin territory reported synthetically on diagrams or photographs.

The aesthesiometer used for the entire human body is the 0.7 gram aesthesiometer (Semmes-Weinstein monofilament #3.84), except:

- for the dorsal side of the hand and foot: 0.4 gram (Semmes-Weinstein monofilament #3.61);
- for palmar and plantar sides: 0.2 gram (Semmes-Weinstein monofilament #3.22);
- for the face: 0.1 gram (Semmes-Weinstein monofilament #2.83).

It should be noted that the following information provides a foundation for the somatosensory rehabilitation of neuropathic pain: the normative values for pressure perception threshold.

Norms for Pressure Perception Threshold
(Weinstein, 1962; Bell-Krotoski et al., 1994; Spicher et al., 2013)

- 0.1 gram on palmar and plantar sides. #3.22 aesthesiometer is detected.
- 0.3 gram on dorsal side of the hands and feet. #3.61 aesthesiometer is detected.
- 0.6 gram on the rest of the body. #3.84 aesthesiometer is detected.

« The objective of the Pressure Perception Threshold (PPT) measurement is to determine the minimum pressure detected, at a specific point. To perform this test, it is necessary fifteen out of the twenty aesthesiometers from the Semmes-Weinstein monofilaments kit graded from 0.03 gram to 75.0 grams. Within the aesthesiography, we determine the most hyposensitive contact area, touching the skin and questioning the patient. It is in this area that a precise point,
reproduced on the sheet of the aesthesiography, will be determined for the realization of the PPT.» (Quintal et al., 2013).

**The cardinal point : topographic element**

The dots indicate where the 0.7 gram application is not detected. The largest area of cutaneous distribution is bounded by its 4 cardinal points. Ex: the most distal point (Fig. 3).

The **green dot** corresponds in Fig. 4 to the most radial point, for example, observed in our series.

In some charts, a **brown point** (Fig. 4) corresponds to a point further from the autonomous territory than the green cardinal point which we had observed, but which is published in the literature (referred to on the chart and cited, also in brown, in the bibliography). Other points published in the literature are not retained because they are less distant from the autonomous territory: Testut (1897); Tinel (1916); Tubiana et al. (1990); Doyle et al. (2003).

![Fig. 4](image)

**Fig. 4 :** The most radial point, on one axis of a cutaneous branch, of the largest territory of cutaneous origin. In this example, **3** is the most radial point published by Sunderland (1978); **2** is the most radial point observed in the dorsal branch of the ulnar nerve; **1** is another point published by Létiévant (1869, 1873), but not retained, because it is not the «most radial» of the largest area of cutaneous origin of this branch.

**The arrow**

The arrow (Fig. 1) indicates the axis and the direction along which the aesthesiometer is applied; either the longitudinal axis or the transversal axis, or even the metacarpophalangeal axis, the metatarsophalangeal axis, etc.

**The triangle**

The triangle indicates the point from which the measures were taken. It corresponds to the theoretical point of origin (0;0) of the orthogonal axes (x;y).
Atlas des territoires cutanés pour le diagnostic des douleurs neuropathiques

3e édition

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