SUDOSCAN

EARLY IDENTIFICATION AND FOLLOW-UP OF PERIPHERAL AUTONOMIC NEUROPATHIES

- Establish diagnosis
- Provide quantitative data to adapt patient care and lifestyle
- Control effectiveness of treatment

3 MINUTES

SIMPLE

NON-INVASIVE

OBJECTIVE

QUANTITATIVE

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SWEAT GLAND FUNCTION – A RELIABLE INDICATOR FOR PERIPHERAL AUTONOMIC NEUROPATHY

Why test sweat gland function?

Sweat glands are innervated by small sympathetic C-fibers. Sudomotor (sweat) dysfunction can be one of the earliest detectable neurophysiologic abnormalities in distal small fiber neuropathies. Quantitative assessment of sweat response has been proposed as an index of the severity of autonomic failure as well as an early indicator for regeneration of small fibers [1,2,3].

Diabetes has been shown to be the most common identifiable cause of small fiber neuropathy. The American Diabetes Association (ADA) has identified sudomotor (sweat) dysfunction as one of the major clinical manifestations of diabetic autonomic neuropathy. Furthermore, the assessment of autonomic dysfunction may identify patients at high risk for cardiac autonomic neuropathy, which carries a very high rate of morbidity and mortality [4].

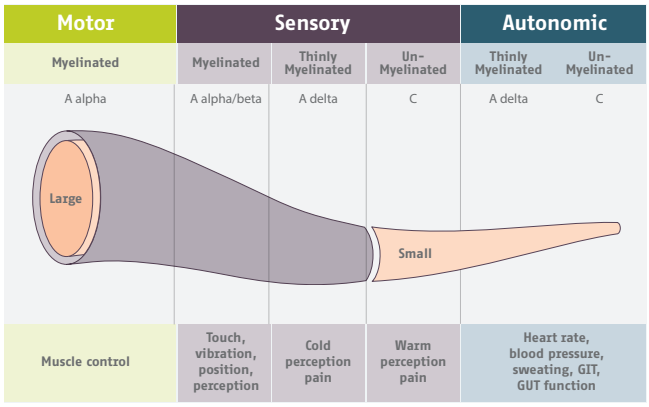

Figure 1: The peripheral nervous system is made of large and small fibers. The small, un-myelinated C-fibers are in charge of autonomic functions such as sweating [Adapted from 5].

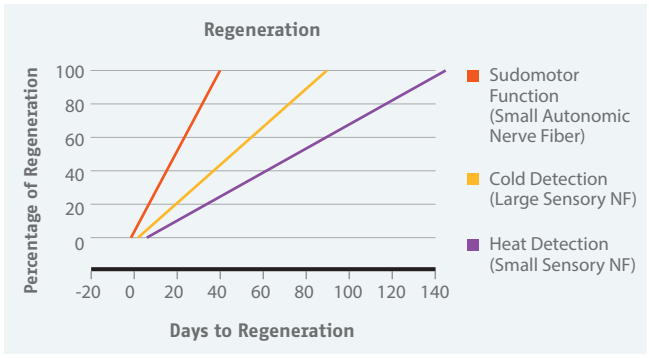

Figure 2: Small fiber autonomic nerves regenerate more quickly than the large fiber nerves upon capsaicin application [Adapted from 3].

What are the alternatives ?

The use of skin biopsy to measure Intraepidermal Nerve Fiber Density (IENFD) or Sweat Gland Nerve Fiber Density (SGNFD) is an accepted surrogate measure of small fiber neuropathy. While skin biopsy is well accepted by the medical community, it has certain limitations as: invasiveness, risk of infection, bleeding, and a limited number of laboratories that can process the sample [6].

The Quantitative Sudomotor Axon Reflex Test (QSART) measures sweat response under controlled humidity and temperature conditions. It requires fairly expensive equipment and is available in few centers.

Laser evoked potential (LEP) is also a sensitive tool to small fiber impairment. Laser-evoked potentials are brain responses to laser radiant heat pulses and mainly reflect the activation of Aδ nociceptors [7]. However, this technique is only available in a limited number of clinical neurophysiology laboratories worldwide.

SUDOSCAN MEASURES THE RESPONSE OF SWEAT GLANDS WHEN ELECTRICALLY STIMULATED

How does it work ?

The degeneration of small nerve fibers reduces sweat gland innervation and alters sudomotor function [8]. Sudoscan measures the electrochemical reaction between chlorides released by the sweat glands in response to electrical stimulation and electrodes in contact with palms and soles.

A low-voltage current (<4V) is applied to the hands and feet through stainless steel sensor electrodes. The applied tension extracts chloride ions from the sweat glands which are densely concentrated on the palms and soles. Since the stratum corneum acts as an isolator, the ions can only pass via the sweat ducts. This ensures that the findings correspond solely to sweat gland function. The chloride ions create a detectable electrochemical reaction with the sensor plates which is measured.

What is measured

SUDOSCAN records the Electrochemical Skin Conductances (ESC) of the hands and feet generated from the current associated with the applied voltage. Loss of sweat glands or damages of their innervations results in reduced ESC [9].

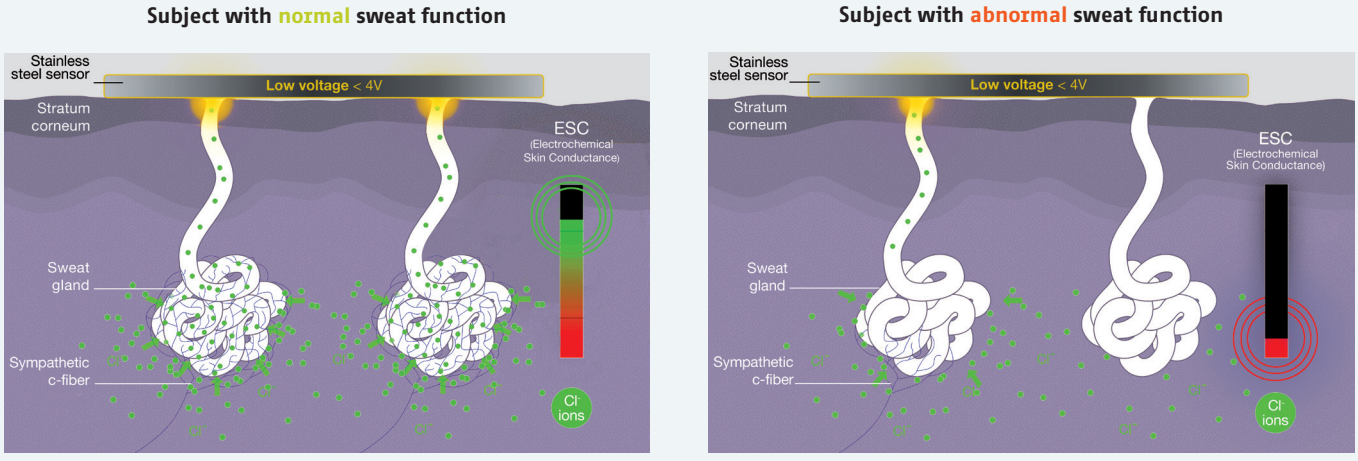

Figure 3: ESC measurement of a subject with normal (left) and abnormal (right) sweat function.

SUDOSCAN ENABLES FAST AND EASY QUANTIFICATION OF SUDOMOTOR FUNCTION

SUDOSCAN at a glance

Fast

- No patient preparation
- Results in 3 minutes
- Automatic reports

Simple

- Non-invasive
- No fasting necessary
- Easy training
- Touch screen operation

Accurate

- Quantitative results
- Proven clinical results
- Operator independent
- Four hands and feet electrodes
- Automatic quality check

Fast testing

SUDOSCAN provides an accurate evaluation of sudomotor function by measuring the ability of sweat glands to release chloride ions in response to an electrical stimulation on the palm of the hands and soles of the feet, areas with the highest sweat gland density [10] in less than 3 minutes.

Clear results

1 Simple

Ergonomic touch screen operation and detailed graphics allow for visual representation of the results. An immediate quality check ensures reliable results. Results are easy to interpret: Green suggests no neuropathy, Yellow a moderate neuropathy and Orange a more severe neuropathy.

2 Quantitative

Actual numerical values of the Electrochemical Skin Conductance (ESC) of each hand and foot are displayed. The level of ESC indicates the severity of the neuropathy. This measure can be compared with later test results to assess the patient's response to treatment or other prescribed interventions or the evolution of the neuropathy.

3 Accurate

Measure of symmetry between right and left sides help identify the type of peripheral neuropathy.

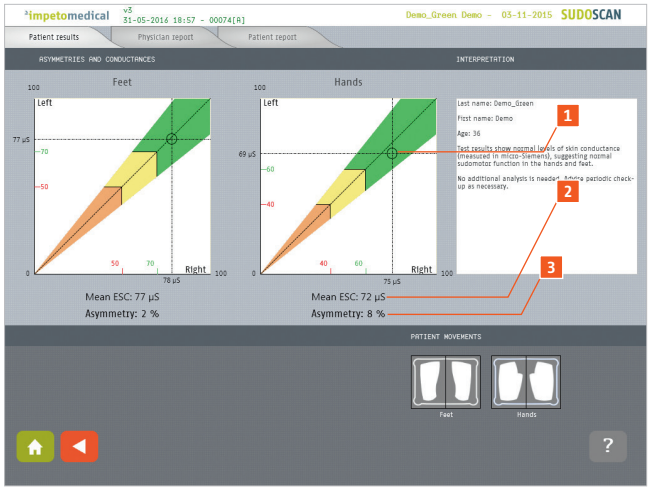

Figure 4: Conductance and asymmetry of hand and feet.

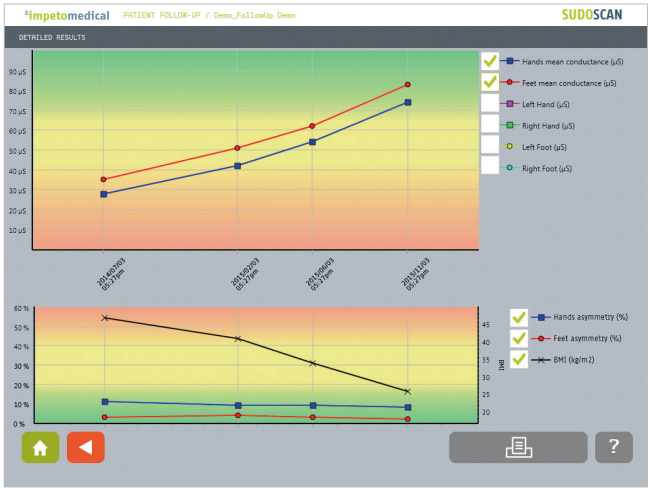

Figure 5: Easy follow-up of the evolution of the neuropathy.

SUDOSCAN FACILITATES PREVENTION, EVALUATION AND FOLLOW-UP OF AUTONOMIC PERIPHERAL NEUROPATHY

A broad range of diseases

Sudomotor dysfunction is a common finding, and one of the earliest detectable abnormalities in a number of peripheral and autonomic neuropathies.

SUDOSCAN has been tested for small fiber nerve neuropathies in several diseases and compared to guidelines reference tests:

- **Diabetes**
- **Parkinson/Multiple System Atrophy**
- **Chemotherapy induced polyneuropathy**
- **Familial amyloid polyneuropathy**
- **Fabry disease**
- **Idiopathic neuropathy**

Sudoscan in international recommendations

In a recent position statement AACE would urge that sudomotor function testing be authorized for all practitioners, include primary care, endocrinology, and podiatry, who see patients with diabetes (position statement AACE). [11]
In a clinical case report in NEJM, Vinik A recommends that autonomic function tests should be performed to obtain a definitive diagnosis and serve as baselines from which the progression or resolution of the neuropathy can be follow (Vinik NEJM 2016). [12]

SUDOSCAN has been included in the testing and management of individual at risk guidelines written by the AT TReuNet Network [13]. In a recent paper (Lancet endocrinology) Tesfaye et al recommends that combination of devices assessing both small and large fibre function should be used for detecting Diabetic Peripheral Neuropathy (Tesfaye Lancet endocrinology 2019). [14]

Diabetes

Diagnosing diabetic neuropathy

Diabetes is the primary identifiable cause of small fiber neuropathy. Early identification of small fiber neuropathy, which may be asymptomatic in up to 50% of diabetes patients, can reduce or delay diabetes complications by timely preventative treatment [4]. The sensitivity and specificity of ESC as measured by Sudoscan to detect diabetic neuropathy based on American Academy of Neurology criteria (AAN) were 88 and 76% respectively [15].

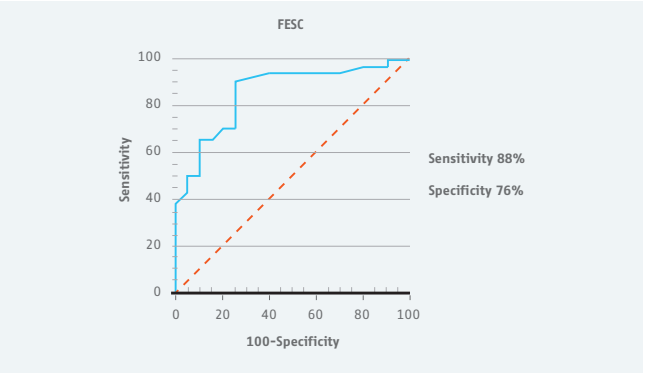

Figure 6: Graphic presentation of the diagnostic performance of Foot Electrochemical Skin Conductance (FESC, µS) by Receiver Operating Curve (ROC) analysis for diabetic peripheral neuropathy [15].

Evaluate cardiac autonomic neuropathy

Cardiovascular Autonomic Neuropathy (CAN) is a common but often overlooked complication of diabetes. Studies have shown that SUDOSCAN may be used for early screening of CAN in everyday clinical practice before resorting to the more sophisticated and specific, but ultimately more time-consuming, Ewing tests [15].

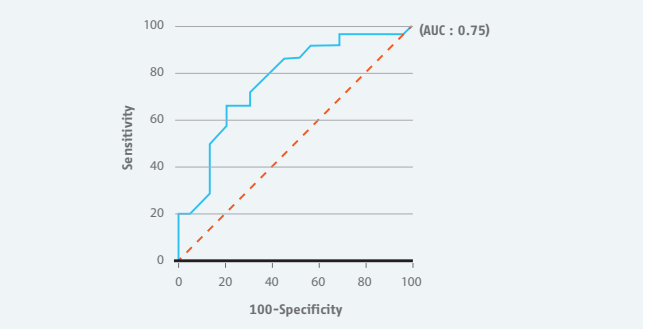

Figure 7: Graphic representation of the diagnostic performance of the SUDOSCAN Cardiac Autonomic Neuropathy risk-score by Receiver Operating Curve (ROC) analysis, using Ewing tests as a gold standard [15].

Follow-up

Diabetes treatment

A significant improvement (of 25%) in feet ESC was observed in patients with type 2 diabetes after treatment with Teneligliptin, 20mg once a day for three months. [16]

Teneligliptin not only improves the glycemic status but also improves sudomotor function, peripheral and autonomic neuropathy in type 2 diabetes.

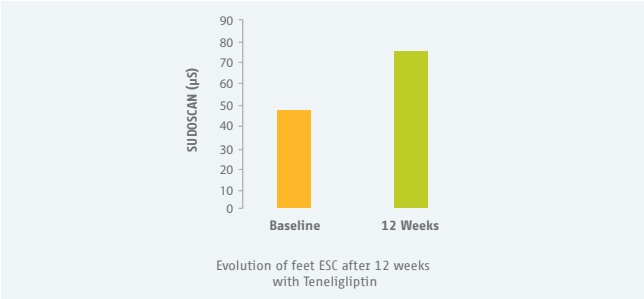

Figure 8: Evolution of feet ESC after 12 weeks with Teneligliptin [16].

Neurology

Positive comparison to IENFD (Skin Biopsy)

SUDOSCAN has demonstrated a diagnostic performance similar to Intra Epidermal Nerve Fiber Density (IENFD) with a sensitivity of 77% and a specificity of 67% [17].

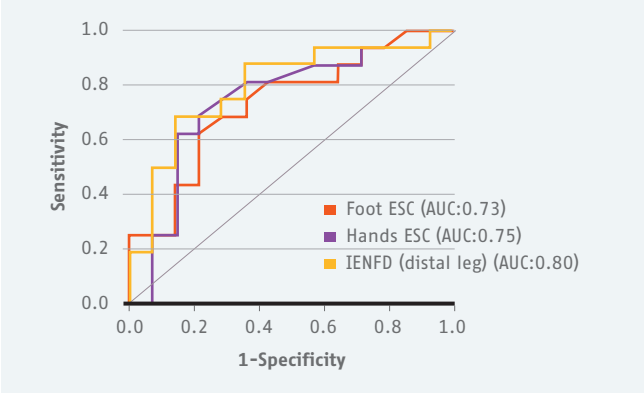

Figure 9: ROC curves for foot and hands ESC and IENFD at the distal leg (using Utah Early Neuropathy Score (UENS) as gold standard) [Adapted from 17].

Oncology

Chemotherapy Induced Polyneuropathy (CIPN)

SUDOSCAN has results parallel to Total Neuropathy Score clinical version (TNSc). SUDOSCAN can easily be performed in the Oncology department, before and after treatment for an optimal follow-up of patients to detect Chemotherapy Induced Polyneuropathy (CIPN) [18].

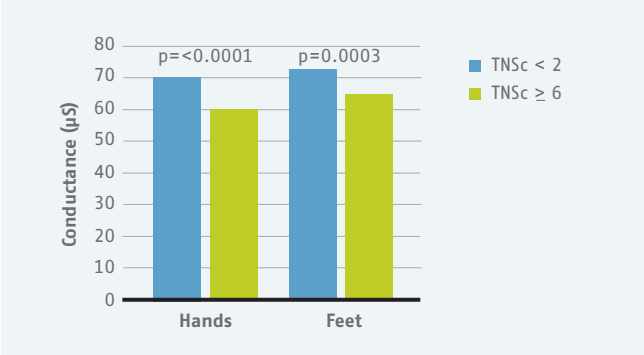

Figure 10: SUDOSCAN scores correlates to TNSc extreme values [18].

Amyloidosis

SUDOSCAN is a sensitive test to assess early autonomic dysfunction in Hereditary transthyretin amyloidosis polyneuropathy subjects and can easily be introduced as a routine assessment in this population [19].

Recently Lefaucheur et al. evidenced that ESC measures did not differ between patients according to the type of TTR variant and were reduced in 24% of clinically asymptomatic patients, 40% of paucisymptomatic patients, 65% of patients with moderate TTR-FAP, and 92% of patients with advanced TTR-FAP. ESC measures were found to correlate with patients' clinical status, especially assessed by the Neuropathy Impairment Score and Karnofsky Performance Status. [20]

More recently Magy et al. evidence that sudomotor dysfunction as assessed by ESC is widespread and prominent in patients with AL amyloidosis, even in asymptomatic ones (Art Magy). [21]

Comparison to other tests for peripheral neuropathies

Detection of Small Fiber Polyneuropathy (SFPN)

SUDOSCAN demonstrates to be an easy, rapid and reliable method compared to other tests to detect Small Fiber Polyneuropathy [22]. Several studies were performed to compare Sudoscan to the reference tests for small fiber neuropathies such as QSART (Art Pavy).

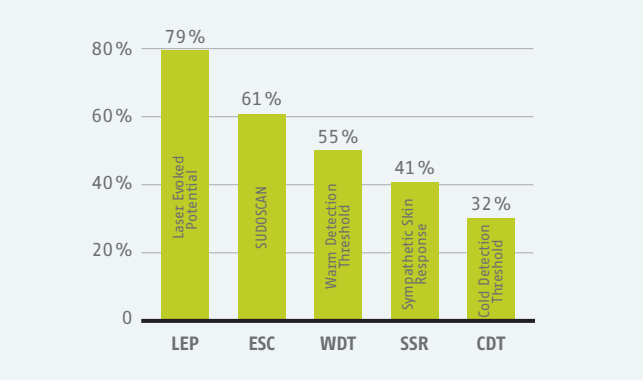

Figure 11 : Diagnostic performance of Laser Evoked Potential (LEP), SUDOSCAN, Warm Detection Threshold, Sympathetic Skin Response (SSR) and Cold Detection Threshold for detecting Small Fiber Polyneuropathy (SFPN) [Adapted from 22].

Discover the benefits of SUDOSCAN in different areas of medical care

Diabetes complications:
Manage diabetic foot and cardiac autonomic neuropathy effectively. Improve diabetes care and patient outcomes.

Neurological complications:
Use Sudoscan to assess small fiber neuropathies associated with various diseases such as hereditary amyloidosis, Hepatitis C, COVID-19, epilepsy, Fabry disease, Parkinson's disease, and more.

Oncology:
Detect chemotherapy-induced polyneuropathy (CIPN) with SUDOSCAN. Monitor nerve health during cancer treatments.

Follow-up:
Track progress and manage patients over time throughout several therapeutic areas. Maintain optimal care for your patients and stay updated about their well-being.

About Impeto Medical

Impeto Medical is a privately owned medical device company formed in June 2005. Its corporate headquarters are located in Issy-Les-Moulineaux, France.

Impeto Medical has developed a technology that assesses sudomotor function through sweat gland activity. This technology is protected by over 50 French and localized patents. With devices sold throughout the world and over 200 publications in peer-reviewed journals, Impeto Medical continues to grow.

Sudoscan is a regulated health product under the CE certification, Class IIa according to the European Medical Device regulation - SGS Belgium, Notified Body 1639

Please read the user manual instructions carefully. Please, contact our office for more information.

SUDOSCAN

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EN-2023-08 – Design: Sographic Communication – Photos: Jean-Lionel Dias