**CASE REPORT**

# Progressive sensory ataxia and breast implant rupture, an uncommon presentation of a debated concept: a case report

Sofie Van Assche[1*†] , Heleen Parmentier[1†], Gaelle Varkas[2], Isabelle Peene[2] and Sarah Herdewyn[1]

## Abstract

**Background:** Autoimmune Syndrome Induced by Adjuvants (ASIA) is a concept introduced by Shoenfeld to group various disease entities believed to be triggered by an infection, silicone exposure or other external stimuli. A causal link between the use of silicone and the development of autoimmune diseases and lymphoma has been suggested in the past. Sjögren's Syndrome (SS) is one of the autoimmune diseases that has been postulated as an example of ASIA syndrome. Although typically characterized by sicca, SS can manifest as a ganglionopathy as the primary presenting symptom. To our knowledge, this is the first case report in which a ganglionopathy unveiled an underlying SS in the context of a possible ASIA syndrome.

**Case presentation:** We describe a case of a 44-year-old woman who developed rapidly progressive sensory loss in the 4 limbs with a walking impairment due to the severe sensory ataxia. After extensive work-up, she was diagnosed with a ganglionopathy as the first symptom of SS, and the concurrent diagnosis of a bilateral breast implant leakage with severe inflammation due to silicone bleeding. After surgical removal of the prostheses and initiation of immunosuppressive therapy, stabilization of symptoms was achieved.

**Conclusion:** This case report brings to attention the possibility of a sensory ganglionopathy as first and isolated symptom of SS. The occurrence of SS in the setting of ASIA stir up the discussion about the safety of silicone breast implants.

**Keywords:** Ganglionopathy, Sjögren's syndrome, ASIA, Silicone

## Background

The Autoimmune/inflammatory Syndrome Induced by Adjuvants (ASIA) is a relatively new concept, introduced in 2011 by Shoenfeld [1]. It is a disease entity consisting of a variety of systemic symptoms. It is thought to have its origin in a triggered immune system due to a certain adjuvant. A possible genetic predisposition is suspected, mainly focusing on the HLA-DRB1, DR5 and DQ2 haplotypes and PTPN22 gene. The systemic symptoms described are divers and often vague: diffuse musculoskeletal pain, fatigue, headache, paresthesia, cognitive impairment, weight loss, unexplained fever, skin abnormalities, hair loss, dry eyes and mouth [2]. However, sometimes a distinctive set of clinical features is observed compatible with known disease entities such as sarcoidosis, Sjögrens's Syndrome (SS), undifferentiated connective tissue disease [3]. An important feature of the ASIA syndrome is that symptoms tend to improve once the causative agent is eliminated. The finding of autoantibodies is possible, although not necessary. Since the introduction of the concept of ASIA, certain triggers have been suggested: drugs, metals, infections, vaccines,... One

†Sofie Van Assche and Heleen Parmentier are first authors.

*Correspondence: sofie_vanassche@hotmail.com

[1] Neurology Department, University Hospital Ghent, 9000 Ghent, Belgium
Full list of author information is available at the end of the article

Van Assche *et al. BMC Neurology* (2022) 22:368

Page 2 of 8

of the triggers also frequently mentioned in literature is silicone, a material that has been considered biologically inert, which has justified its broad use in medical devices and for instance in reconstructive surgery with breast implants. The following case report concerning a suspected case of ASIA triggered by silicone breast implant rupture is remarkable both in its initial clinical presentation as in the possible underlying disease mechanism.

## Case presentation

### Case description

A 44-year-old female presented at our emergency department with a rapidly progressive sensory loss of the lower limbs combined with severe balance difficulties.

Her medical history included atopic eczema, gastric banding and plastic surgery for breast augmentation. Both surgeries had taken place almost 20 years ago. There were no relevant findings in her family history. Aside from vitamin B and folic acid, started recently because of the symptoms, she denied taking any prescription drugs.

Three months earlier, her symptoms had started with paresthesia and dysesthesia in her feet and lower part of her legs, more prominent on the right side. The nerve conduction studies (NCS) and electromyography (EMG) were only minimally abnormal with an increased latency of the sural nerve sensory nerve action potential (SNAP). Given her complaints, there was a suspicion of a sensory polyneuropathy. The initial work-up before presentation at our hospital, showed a mild lymphocytosis (3.42; reference value $1-3.2 \times 10^3/mm^3$) and serum folic acid deficiency (2.5; reference value 3.9–26.8 µg/L). Vitamin B12 was normal (369 nmol/L, reference values 197–779 nnmol/L). Vitamin B and folate substitution were started. Contrast-enhanced lumbar and cervical spine magnetic resonance imaging (MRI) did not show any abnormalities. A brain MRI with gadolinium was also normal. Two months after the onset of symptoms, a lumbar puncture was performed, which showed a marginally elevated white blood cell count (7.2; reference value 0–5/µL), normal glucose (52, reference value 40-70 mg/dL), in the absence of protein elevation (74.1; reference value 64-83 g/L). However, there was a raised IgG index (0.97; reference value 0.3–0.77) and three supplementary bands in the cerebrospinal fluid on iso-electrical focusing. Because an underlying autoimmune disease was suspected, erythrocyte sedimentation rate, antinuclear antibodies (ANA) and anti-neutrophil cytoplasmic antibodies (ANCA) were checked. Erythrocyte sedimentation appeared slightly elevated, whereas ANCA and ANA were found to be negative, aside from cytoplasmic staining with AC 18 pattern on indirect immunofluorescence on HEp-2 cells. Vitamin B6 level was elevated (1430 nmol/L, reference values 35–110 nmol/L), but was measured after starting substitution and not-fasting.

Three months after onset, the patient was referred to our tertiary centre for further work-up. By this time, the paresthesia in her distal lower limbs had evolved to a numbness of both legs, chest and back. Since a few weeks her hands were also involved in an asymmetrical and patchy pattern. Meanwhile, she had developed a severe gait instability, especially when walking barefoot or in the dark, resulting in multiple falls. Apart from fluctuating paresthesia in her face (especially in the left lower cheek), there was no other cranial nerve involvement: no diplopia, no dysarthria or dysphagia, no signs of facial palsy.

At first clinical evaluation, she had normal strength in both upper and lower limbs, but global areflexia. She had severe sensory deficits with almost absent vibration sensation, impaired proprioception and absent graphesthesia in the lower limbs. She indicated a sensory level around Th 7–8. There was severe ataxia in both legs, both on heel-to-shin test as on walking. She was unstable, needed support and had to look at her feet, which exhibited a pseudo-athetosis when walking.

### Investigations

The patient was admitted to our neurology department for further work-up. Given the new sensory symptoms in the face and the sensory level, neuroimaging was repeated with contrast-enhanced MRI of the brain and the full spine without signs of central demyelination or peripheral inflammation.

Nerve conduction studies now showed bilateral absent sural nerve SNAPs and undetectable right ulnar nerve SNAP. Right median nerve SNAP was still normal, but right radial and left ulnar SNAP were markedly reduced (with an amplitude of respectively 4 µV and 6 µV, normal values >11 µV). Motor responses were normal, as well as needle EMG findings and blink reflex. Somatosensory evoked potentials showed a normal N8-latency (at the popliteal fossa), no detectable responses in the lumbar region (possibly constitution-related), an absent cortical response from the right leg and a delayed cortical response from the left leg. In summary, electrophysiological testing revealed a non-length dependent, asymmetric loss of SNAPs, best in keeping with a sensory ganglionopathy.

MRI full spine did not show the dorsal column atrophy that is sometimes seen in the chronic phase of a ganglionopathy [4, 5], but this could well be due to the early timing of the imaging in the disease course.

Laboratory results were negative for paraneoplastic antibodies, anti-ganglioside antibodies, anti-aquaporin 4/anti-neuromyelitis optica (NMO), anti-myelin

oligodendrocyte glycoprotein (MOG) and coeliac antibodies. Further, we noted a HbA1C of 5.8%, with normal serum protein electrophoresis and copper levels. Following vitamin levels were normal (i.e. vitamin B1 252 nmol/L reference values 67-200 nmol/L; B12 542 ng/L, reference values 197–771 ng/L; folic acid > 20 µg/L; vitamin E 1.4 mg/dL, reference values 0.5–1.8 mg/dL), as well as homocysteine and methylmalonic acid. Vitamin B6 was somewhat elevated (vitamin B6 585 nmol/L, reference values 35-110 nmol/L), but likely not-fasting. These levels were measured while already taking vitamin supplements (combination of folic acid and vitamin B1-B2-B6-B12). Serology for Human Immunodeficiency Virus (HIV), Hepatitis (A/B/C/E), Herpes Simplex, Varicella Zoster, Borrelia/Lyme, and Syphilis were all negative. Auto-immune screening for rheumatoid factor, anti-cyclic citrullinated peptide, ANA, ANCA, cryoglobulinemia and complement levels revealed atypical ANCA (4+) and ANA (2+) with further extractable nuclear antigen (ENA) differentiation positive for anti-Ro52 antibodies.

A clinical evaluation by the rheumatologists was requested, given the anti-Ro52 antibodies and suspicion of SS. There were no signs suggestive of connective tissue disease, e.g. no Raynaud phenomenon, arthralgia/myalgia, glandular swelling, sicca (xerostomia, xerophthalmia), cough, dyspnoea, nor signs of autonomic dysfunction. Ultrasonography revealed heterogenicity of the submandibular gland. Subsequent biopsy of the minor salivary glands confirmed a focus score of more than one, a histopathological finding compatible with SS (Fig. 1). Additionally, performing a Schirmer's test could have been useful, though the patient was not open to this.

A full body positron emission tomography-computed tomography (PET-CT) showed enlarged lymph nodes extending from the left axilla to the left side of the left breast prosthesis and alongside the left thoracic internal artery (Fig. 2). Additional dedicated ultrasonography confirmed leakage of silicone of both breast implants and enlarged lymph nodes compatible with silicone lymphadenopathy. Biopsy confirmed lymphoid tissue surrounding silicone material and could exclude a lymphoma (Fig. 3).

## Treatment

The ruptured breast implants were resected 1 month after the presentation at our emergency department. A few days later, our patient reported an improvement of her general well-being and a stagnation of the - until then - progressive sensory complaints. The reported paresthesia in her face disappeared before any additional therapy was started, but the overall clinical picture remained stable over the next month. Vitamin B supplementation was stopped. After exclusion of malignancies in the resected breast tissue, oral corticosteroid therapy was initiated (at a dose of 60 mg prednisolone a day) in association with hydroxychloroquine 200 mg
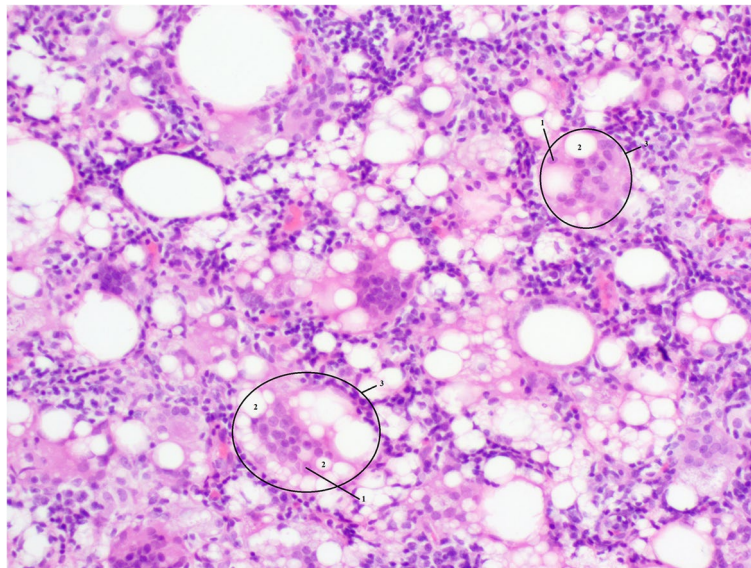


**Fig. 1** Biopsy of lymph node. Lymph node biopsy with foreign body giant cell reaction and the presence of macrophages containing clear, refractile, nonpolarizable material within cytoplasmic vacuoles. Hematoxylin&Eosin (HE) staining; original magnification 200x. 1 nucleus of one macrophage, 2 silicone particle, 3 cluster of macrophages surrounding silicone particles. Technical information: Obtained using Olympus BX53 microscope; Olympus PlanC 4x/0.10, 10x/0.25, 20x/0.40, 40x/0.65 objective lenses; Olympus 10x/22 oculars; Toupcam industrial digital camera UCMOSO5100KPA 6.1 MP 1/2.5″ APTINA CMOS SENSOR P/N: TP605100A UCMOS Touptek Photonics, Olympus U-TV0.5XC-3; serial number filter 7E44103 201,705; Toupview software by Touptek. No downstream processing or averaging was applied
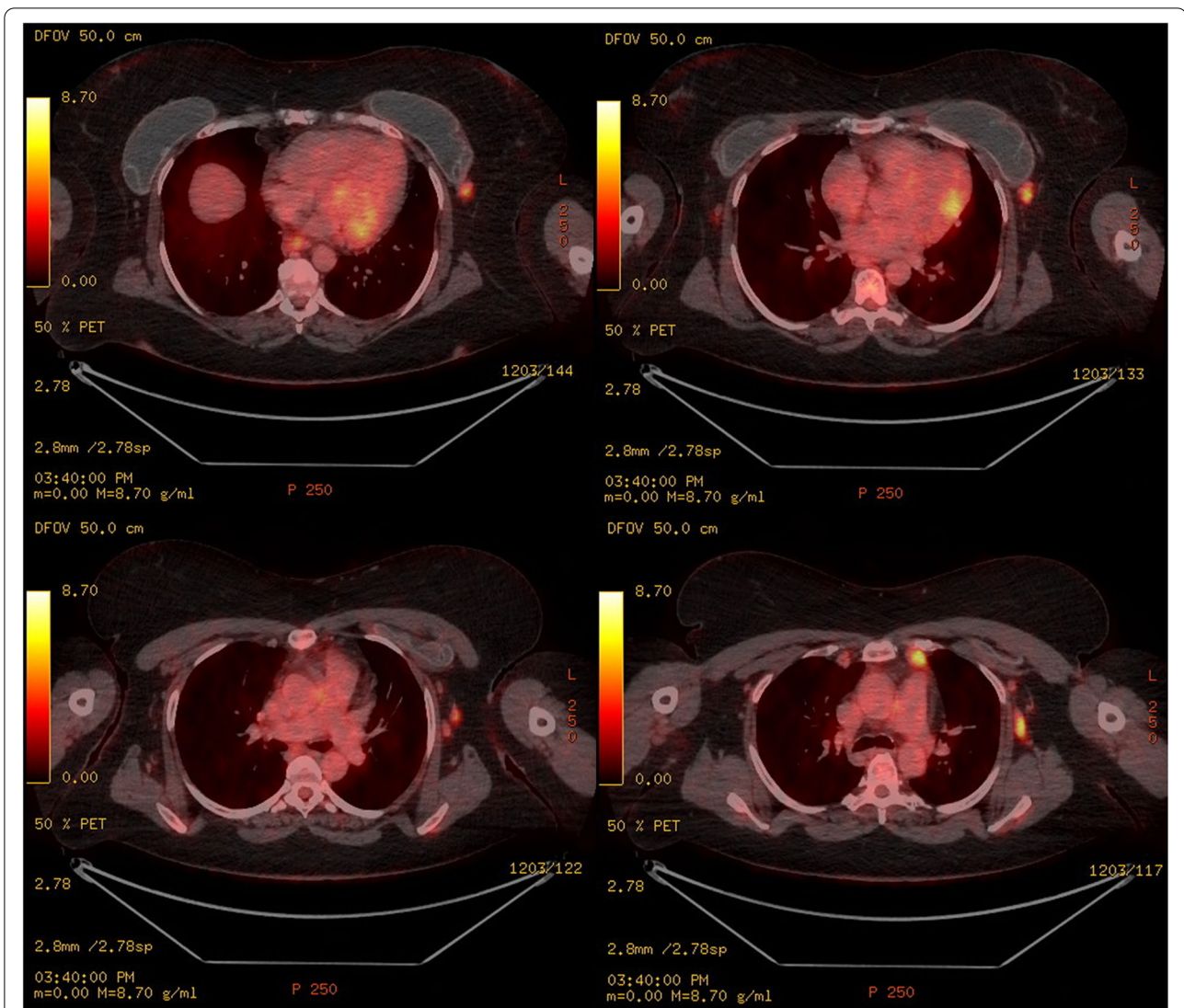
Van Assche *et al. BMC Neurology*      (2022) 22:368

Page 4 of 8



**Fig. 2** PET-CT imaging. PET-CT displaying hypermetabolic, enlarged lymph nodes, predominantly at the left side. Heterogenic content of the subpectoral breast prosthesis, suggestive of rupture

two times daily and methotrexate 15 mg once a week with folic acid 1 mg daily for 6 days a week. Preventive measures with a proton-pump inhibitor, calcium supplement, Vit D, trimethoprim/sulphametoxazole 160 mg/800 mg (3 times a week) and weekly bisphosphonates were added to her therapy. Steroids were tapered by 10 mg a month. At 3 months follow-up, she did not report new improvement of her symptoms. However, repeated NCS did show a clear amelioration with presence of sural and ulnar SNAP and a normalised radial SNAP. Further follow-up is necessary to show whether there will be clinical improvement.

## Discussion and conclusions

We report a case of ganglionopathy as a first manifestation of SS, in a broader context of ASIA syndrome. The latter highlights the coexistence of some syndromes and concepts classified under the title of Autoimmune/inflammatory Syndrome Induced by Adjuvants (ASIA) [1]. We briefly discuss the different disease entities and try to link them as a whole.

*Ganglionopathy* is typically characterised by an asymmetric, non-length dependent sensory deficit with severe ataxia and areflexia at clinical examination [6]. Facial involvement, autonomic dysfunction, cerebrospinal fluid (CSF) pleocytosis and oligoclonal bands have been reported [7]. Proposed diagnostic criteria by
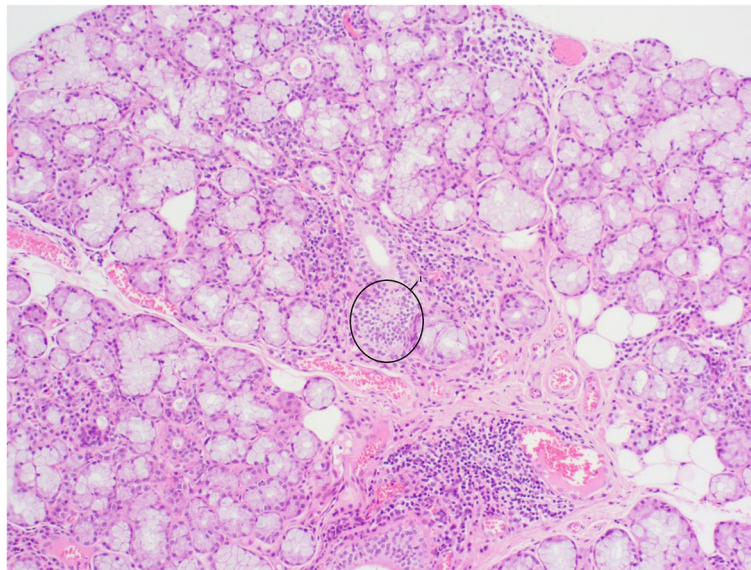
Van Assche *et al. BMC Neurology*     (2022) 22:368

Page 5 of 8



**Fig. 3** Biopsy of minor salivary gland. Biopsy of minor salivary gland tissue. Hematoxylin&Eosin (HE) staining; original magnification 200x. 1 lymphocytic focus of >50 lymphocytes. Technical information: Obtained using Olympus BX53 microscope; Olympus PlanC 4x/0.10, 10x/0.25, 20x/0.40, 40x/0.65 objective lenses; Olympus 10x/22 oculars; Toupcam industrial digital camera UCMOSO5100KPA 6.1 MP 1/2.5″ APTINA CMOS SENSOR P/N: TP605100A UCMOS Touptek Photonics, Olympus U-TV0.5XC-3; serial number filter 7E44103 201,705; Toupview software by Touptek. No downstream processing or averaging was applied

Camdessanché et al. are shown in Table 1. Our patient had a score of 12.7 (Aa, Ab, Ac, Ad, Ae) and therefore fulfilled the criteria for probable ganglionopathy (Ba and Bbv).

*Primary Sjögren's syndrome* (pSS) is known for its glandular tropism, but the typical sicca symptoms can be accompanied or even preceded by many different extra-glandular manifestations as reflected by the European Sjögren's Syndrome activity index (ESSDAI) such as constitutional symptoms, lymphadenopathy, articular involvement, cutaneous involvement, pulmonary involvement, renal involvement, peripheral/central nervous system involvement and/or haematological involvement [8–12]. The diagnosis of SS is ultimately made clinically, supported by the 2016 ACR-EULAR criteria, as presented in Table 2 [13, 14].

Neurological involvement is seen in 20% of the patients with primary SS (pSS), with peripheral nervous system

**Table 1** Criteria sensory neuronopathy (SN) as proposed by Camdessanché et al. [7]

| | |
|---|---|
| **A—Possible SN** if score >6,5 | |
| (a) Ataxia in the lower or upper limbs at onset or full development | 3.1 |
| (b) Asymmetrical distribution of sensory loss at onset or full development | 1.7 |
| (c) Sensory loss not restricted to the lower limbs at full development | 2.0 |
| (d) At least 1 SNAP absent or 3 SNAP <30% of the lower limit of normal in the upper limbs, entrapment neuropathies excluded | 2.8 |
| (e) <2 nerves with abnormal motor nerve conduction studies in the lower limbs | 3.1 |
| **B—Probable SN** if score >6,5 AND (a) AND ((b) or (c)) | |
| (a) The initial workup does not show biochemical or electrophysiological findings excluding SN | |
| (b) The patient has one of the following:<br>    i. diagnosis of cancer within 5 years<br>    ii. cisplatin treatment<br>    iii. Detection of onconeural AB<br>    iv. diagnosis of an HIV infection<br>    v. Sjögren's syndrome | |
| (c) MRI shows T2-hyperintensity in the posterior column of the spinal cord | |
| **C—Definite SN** pathological demonstration of dorsal root ganglia degeneration trough biopsy | |

Van Assche *et al. BMC Neurology*     (2022) 22:368

Page 6 of 8

**Table 2** ACR-EULAR criteria for Sjögren's syndrome as proposed by Ramos-Casals M, Brito-Zerón P, Bombardieri S, et al. [13]

| Diagnosis Sjögren's syndrome if A and C present, B excluded | |
|---|---|
| A— Inclusion criteria at least one of the following | |
|    (a) oral or ocular dryness based on questioning | |
|    (b) suspicion of SS with at least 1 positive item on ESSDAI[A] | |
| B— Exclusion criteria | |
|    (a) head or neck irradiation | |
|    (b) AIDS, active hepatitis C | |
|    (c) sarcoidosis, amyloidosis, IgG4-related disease | |
|    (d) graft versus host disease | |
| C— Score $\geq 4$ | |
|    (a) labial salivary gland with focal lymphocyte sialadenitis and focus score $\geq 1$ | 3 |
|    (b) anti-SSA (Ro) antibodies | 3 |
|    (c) ocular staining score[B] $\geq 5$, or Van Bijsterveld score[C] $\geq 4$ in at least one eye | 1 |
|    (d) Schirmer's test $\leq 5$ mm in 5 minutes in at least one eye | 1 |
|    (e) unstimulated whole saliva[D] flow rate $\leq 0,1$ ml/min | 1 |

A ESSDAI: The EULAR Sjögren's Syndome Disease Activity Index.

B described in Whitcher et al. [15]

C described in Van bijsterveld et al. [16]

D described in Navazesh and Kumar [17]

symptoms in 5–20% and central nervous system symptoms in 1–5% [9]. Sensory neuronopathy (SN) or ganglionopathy is considered a rare manifestation of pSS, but can be the first presentation [18]. Pereira et al. described a group of 13 patients with a SN due to pSS of whom 11 patients had a SN at first presentation [19]. Although rare, pSS is the most common underlying autoimmune disease in a patient presenting with sensory ganglionopathy, as was true for our patient.

The debated concept of an *Autoimmune/inflammatory Syndrome Induced by Adjuvants (ASIA)* was introduced in 2011 by Shoenfeld to group different medical conditions with the same presumed pathophysiological background, being siliconosis, Gulf War Syndrome, macrophage myophaciitis, sick building syndrome and post-vaccination phenomena. The concept of the disease entity is based on the underlying idea that exposure to certain materials (adjuvants) can induce an immunological response in susceptible individuals. The predisposition is thought to be genetically linked to certain HLA haplotypes (HLA-DRB1, DR5; DQ2 and PTPN22 gene) [1, 20, 21]. The most reported symptoms for ASIA are rather vague, but distinct syndromes have been recognised. The diagnostic criteria proposed are listed in Table 3. Our patient fulfilled all the major criteria.

The first silicone breast implant dated from the early 60s. Silicone was mistakenly thought to be inert in the human body. Already in 1964 Mioshy et al. described the occurrence of connective tissue disease after cosmetic surgery. This was further illustrated by animal models showing an inflammatory response around injection sites of silicone with attraction of leukocytes (macrophages, plasma cells, eosinophils), fibroblasts and formation of fibrous adhesions and histiocytic granulomas [23]. Also, more recently, antibody production after silicone instillation in genetically predisposed mice has been demonstrated [24, 25]. This inflammatory response has also been shown in humans with axillary lymphadenopathy, with formation of fibrous capsules and silicone granulomas after leakage of silicone breast implantation and/or dermal injections of silicone [23, 26, 27]. Case reports and cohort studies suggest that apart from a local inflammatory response (directly adjacent to the breast implant and in lymphoid tissue of the axilla and the thoracic chain), also a more general systemic reaction to silicone breast implantation is triggered [2, 28, 29].

More specifically, different case reports and case series report development of SS following silicone exposure [30, 31]. Although still debated, epidemiological studies have shown an increased risk of developing auto-immune disease after silicone breast implantation. For instance, for SS, an increased odds ratio of 1.58 was seen in women with silicone breast implants compared to controls [32]. A large systematic review could not determine a causal relationship between silicone breast implants and connective tissue disease, but the higher prevalence of SS in patients with silicone breast implantation was confirmed [23, 33].

It is important to mention that a lymphoma was excluded by biopsy, given the fact that the FDA warned in

Van Assche *et al. BMC Neurology*     (2022) 22:368

Page 7 of 8

**Table 3** Criteria ASIA syndrome as proposed by Shoenfeld et al. [1, 3]

| |
|---|
| **A—Major criteria** |
| (a) exposure to an external stimulus prior to clinical manifestation (e.g. infection, vaccine, silicone, ...) |
| (b) typical clinical manifestations<br>    I. myalgia, myositis or muscle weakness<br>    II. arthralgia and/or arthritis<br>    III. chronic fatigue, sleep disturbances<br>    IV. neurological manifestations<br>    V. cognitive impairment<br>    VI. pyrexia, dry mouth |
| (c) removal of trigger induces improvement |
| **B— Minor criteria** |
| (a) autoantibodies or antibodies directed against the adjuvant |
| (b) specific HLA (e.g. HLA DRB1, HLA DQB1) |
| (c) evolvement of an autoimmune disease (e.g. SSc) |

Throughout the literature there appears to be a consensus that having either two major criteria, or one major and two minor criteria, is sufficient for a diagnosis of ASIA [21, 22]

2019 for the higher risk of development of lymphoma in patients with breast augmentation, while the risk of lymphoma is also increased in SS [17] .

In this case presentation, the history of gastric banding is important, given the possibility of vitamin deficiencies (mostly B12) after bariatric surgery [34, 35]. However, in our patient Vitamin B12 levels have always been normal. Serum folic acid level was slightly low, but with normal homocysteine and methylmalonic acid. Furthermore, a vitamin B12 and folic acid deficiency are not known to cause a true sensory neuronopathy. A contributing factor of a possible B1 deficiency was not totally excluded, as she was seen by us after starting vitamin B substitution. However, thiamine deficiency presents with a length dependent polyneuropathy and our patient had a non-length dependent process i.e. ganglionopathy. Vitamin B6 toxicity can cause a ganglionopathy, but the blood samples to measure this were taken while on substitution therapy and (probably) not-fasting. Additionally, substitution was started after the first complaints and the symptoms had already improved before withholding the vitamin supplements. Thus, in this patient, the gastric banding and substitution therapy, are highly unlikely to explain the clinical picture.

In conclusion, we encountered a rare clinical presentation of SS in which the patient developed a sensory ganglionopathy without other typical symptoms of SS. In the work-up towards her diagnosis we found leakage of silicone breast implant causing a local inflammatory response both on imaging and biopsy. After resection of the prosthesis, she reported a stabilization to slight improvement of her symptoms. The timing of diagnosis of both medical problems, the spontaneous improvement after resection and the existing evidence from literature underscore a causal relationship between the silicone leakage and the development of SS in this patient. The whole picture can well be an example of an ASIA syndrome.

The occurrence of SS in the setting of ASIA stir up the discussion about the safety of silicone breast implants. Removal of the breast implants in our patient in combination with immunosuppressive therapy halted the progression of the ganglionopathy with mild perceived improvement and a clear favourable evolution on NCS. Further evolution is to be awaited, but it is known that improvement of a SN can take many months to years and is often incomplete [6].

Development of SS following silicone exposure has been reported previously. However, to our knowledge, this is the first case report where a sensory ganglionopathy was the initial presentation of an ASIA syndrome.

**Authors' contributions**
SVA and HP were responsible for drafting the manuscript. SH was responsible for the intellectual content and revision of the manuscript. GV and IP. were responsible for evaluating the manuscript and the intellectual content focusing on the rheumatological aspects in this case report. All authors have read and approved the manuscript.

Van Assche *et al. BMC Neurology*     (2022) 22:368

Page 8 of 8

### Author details
[1]Neurology Department, University Hospital Ghent, 9000 Ghent, Belgium. [2]Rheumatology Department, University Hospital Ghent, 9000 Ghent, Belgium.

### References

1. Shoenfeld Y, Agmon-Levin N. "ASIA" - autoimmune/inflammatory syndrome induced by adjuvants. J Autoimmun. 2011;36:4–8.
2. Nesher G, Soriano A, Shlomai G, Iadgarov Y, Shulimzon TR, Borella E, et al. Severe Asia syndrome associated with lymph node, thoracic, and pulmonary silicone infiltration following breast implant rupture: experience with four cases. Lupus. 2015;24:463–8.
3. Borba V, Malkova A, Basantsova N, Halpert G, Andreoli L, Tincani A, et al. Classical examples of the concept of the ASIA syndrome. Biomolecules. 2020;10:1–17.
4. Birnbaum J, Lalji A, Piccione EA, Izbudak I. Magnetic resonance imaging of the spinal cord in the evaluation of 3 patients with sensory neuronopathies: diagnostic assessment, indications of treatment response, and impact of autoimmunity: a case report. Medicine. 2017;96:e8483.
5. Casseb RF, Martinez ARM, de Paiva JLR, França MCJ. Neuroimaging in sensory Neuronopathy. J Neuroimaging. 2015;25:704–9.
6. Amato AA, Ropper AH. Sensory Ganglionopathy. N Engl J Med. 2020;383:1657–62.
7. Camdessanché JP, Jousserand G, Ferraud K, Vial C, Petiot P, Honnorat J, et al. The pattern and diagnostic criteria of sensory neuronopathy: a case-control study. Brain. 2009;132:1723–33.
8. Perzyńska-Mazan J, Maślińska M, Gasik R. Neurological manifestations of primary sjögren's syndrome. Reumatologia. 2018;56:99–105.
9. McCoy SS, Baer AN. Neurological complications of Sjögren's syndrome: diagnosis and management. Curr Treatm Opt Rheumatol. 2017;3:275–88.
10. Alunno A, Carubbi F, Bartoloni E, Cipriani P, Giacomelli R, Gerli R. The kaleidoscope of neurological manifestations in primary Sjögren's syndrome. Clin Exp Rheumatol. 2019;37:S192–8.
11. Allarés LUP, Len JACA, Ervera RIC, Ont JOF, Ngelmo MII. Primary Sjögren syndrome clinical and immunologic disease patterns in a cohort of 400. Patients. 2002;81:270–80.
12. Seror R, Ravaud P, Bowman SJ, Baron G, Tzioufas A, Theander E, et al. EULAR Sjogren's syndrome disease activity index: development of a consensus systemic disease activity index for primary Sjogren's syndrome. Ann Rheum Dis. 2010;69:1103–9.
13. Ramos-Casals M, Brito-Zerón P, Bombardieri S, Bootsma H, de Vita S, Dörner T, et al. EULAR recommendations for the management of Sjögren's syndrome with topical and systemic therapies. Ann Rheum Dis. 2020;79:3–18.
14. Shiboski CH, et al. 2016 classification criteria for primary Sjögren's syndrome: a consensus and data-driven methodology involving three international patient cohorts. Ann Rheum Dis. 2016;69:35–45.
15. Whitcher JP, Shiboski CH, Shiboski SC, Heidenreich AM, Kitagawa K, Zhang S, et al. NIH Public Access. 2012;149:405–15.
16. van Bijsterveld OP. Diagnostic tests in the sicca syndrome. Arch Ophthalmol. 1969;82:10–4.
17. Navazesh M, Kumar SKS. Measuring salivary flow: challenges and opportunities. J Am Dent Assoc. 2008;139(Suppl):35S–40S.
18. Bouraoui A, Bari SF. Unusual presentation of Sjögren's syndrome. BMJ journals. 2014;2014:bcr2014206489.
19. Pereira PR, Viala K, Maisonobe T, Haroche J, Mathian A, Hié M, et al. Sjögren sensory neuronopathy (Sjögren Ganglionopathy) long-term outcome and treatment response in a series of 13 cases. Medicine (United States). 2016;95:1–6.
20. Watad A, Bragazzi NL, Amital H, Shoenfeld Y. Hyperstimulation of adaptive immunity as the common pathway for silicone breast implants, autoimmunity; and lymphoma of the breast. Isr Med Assoc J. 2019;21:517–9.
21. Hawkes D, Benhamu J, Sidwell T, Miles R, Dunlop RA. Revisiting adverse reactions to vaccines: a critical appraisal of autoimmune syndrome induced by adjuvants (ASIA). J Autoimmun. 2015;59:77–84.
22. Carvalho JF, Barros SM. ASIA or Shoenfeld's syndrome: a novel autoimmune syndrome? Rev Bras Reumatol. 2010;50:487–8.
23. Busch H. Silicone toxicology. Semin Arthritis Rheum. 1994;24(1 SUPPL. 1):11–7.
24. McDonald AH, Weir K, Schneider M, Gudenkauf L, Sanger JR. Silicone gel enhances the development of autoimmune disease in New Zealand black mice but fails to induce it in BALB/cAnPt mice. Clin Immunol Immunopathol. 1998;87:248–55.
25. Schaefer CJ, Wooley PH. The influence of silicone implantation on murine lupus in MRL lpr/lpr mice. J Rheumatol. 1999;26:2215–21.
26. Wang LL, Thomas WW, Friedman O. Granuloma formation secondary to silicone injection for soft-tissue augmentation in facial cosmetics: mechanisms and literature review. Ear Nose Throat J. 2018;97:46–51.
27. de Faria Castro Fleury E, D'Alessandro GS, Wludarski SCL. Silicone-induced granuloma of breast implant capsule (SIGBIC): histopathology and radiological correlation. J Immunol Res. 2018;2018:6784971.
28. Bretaudeau C, Vaysse C, Guerby P, Lairez O, Soule-Tholy M, Vidal F, et al. Pericarditis after breast implant rupture: a case report. Cardiol Res. 2018;9:381–4.
29. Maijers MC, de Blok CJM, Niessen FB, van der Veldt AAM, Ritt MJPF, Winters HAH, et al. Women with silicone breast implants and unexplained systemic symptoms: a descriptive cohort study. Neth J Med. 2014;71:534–40.
30. Akyol L, Onem S, Ozgen M, Sayarlioglu M. Sjögren's syndrome after silicone breast implantation. Eur J Rheumatol. 2015;2:165–6.
31. Cohen Tervaert JW, Kappel RM. Silicone implant incompatibility syndrome (SIIS): a frequent cause of ASIA (Shoenfeld's syndrome). Immunol Res. 2013;56:293–8.
32. Watad A, Rosenberg V, Tiosano S, Tervaert JWC, Yavne Y, Shoenfeld Y, et al. Silicone breast implants and the risk of autoimmune/rheumatic disorders: a real-world analysis. Int J Epidemiol. 2018;47:1846–54.
33. Balk EM, Earley A, Avendano EA, Raman G. Long-term health outcomes in women with silicone gel breast implants. Ann Intern Med. 2016;164:164–75.
34. Coupaye M, Puchaux K, Bogard C, Msika S, Jouet P, Clerici C, et al. Nutritional consequences of adjustable gastric banding and gastric bypass: a 1-year prospective study. Obes Surg. 2009;19:56–65.
35. Majumder S, Soriano J, Louie Cruz A, Dasanu CA. Vitamin B12 deficiency in patients undergoing bariatric surgery: preventive strategies and key recommendations. Surg Obes Relat Dis. 2013;9:1013–9.

## Publisher's Note
Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.