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# Italian multicenter study on venous hemodynamics in multiple sclerosis: Advanced Sonological Protocol

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Transient global amnesia

**Summary** Because of the recent hypothesis of involvement of the venous hemodynamics in multiple sclerosis (MS), and because of the pitfalls of these studies, there is the need to achieve a definite conclusion from a large sample of subjects by using a strict and controlled neurosonological protocol. The aim of the advanced protocol, designed for a subgroup of the FISM study, is to analyze several items of the venous hemodynamics in order to obtain more pathophysiological data on venous circulation. *Advanced Ultrasound Protocol*: This is a multicenter, observational study. From a pool of about 1200 adults with MS, 400 healthy subjects and 400 subjects with other neurodegenerative disorders (2000 subjects in total) will be selected a population able to be examined by the advanced protocol. The examiner will always be blind on the clinical diagnosis, and the exams will be performed according to a standard protocol, whose measurements are mandatory for all participating centers. The advanced protocol is on a voluntary basis and it is optional. It includes, besides the basic one, measurements of blood flow volumes in carotid and vertebral arteries and in jugular and vertebral veins (inflow and outflow), with the definition of the drainage pattern. The ultrasound examination at each clinical site will

*Abbreviations:* BF, blood flow; BVR, basal vein of rosenthal; CCSVI, chronic cerebro spinal venous insufficiency; CSA, cross-sectional area; ΔCSA, difference between J2 IJV CSA in upright position and J2 IJV CSA in supine position; FISM, Italian Foundation on Multiple Sclerosis; ICA, internal carotid artery; IJV, internal jugular vein; MRI, magnetic resonance imaging; MS, multiple sclerosis; SRS, straight sinus; TAV, time averaged velocity; TCCS, transcranial color-coded duplex sonography; TS, transverse sinus; VA, vertebral artery; VV, vertebral vein.

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be followed by a second centralized blinded evaluation. The prevalence of CCSVI in MS will be estimated, with confidence intervals at 95%, and compared with the prevalence in other groups. Moreover, multiple analysis will be done comparing venous hemodynamics in the three different groups.


## Introduction

Recently a vascular hypothesis about the cause of MS was proposed [1,2], pursuing the impairment of the cerebral venous drainage as a main factor in determining the manifestation of the disease and the disability, through the combination of multiple site venous lesions, mainly in the extracranial location. Five criteria were elaborated for the ultrasound identification of the more significant venous abnormalities (four criteria for the extracranial veins and one criterion for the intracranial veins), and the authors proposed that the presence of two or more positive criteria are diagnostic for a congenital malformation of the venous outflow, called by them CCSVI [2,3]:

1. reflux constantly present in IJV or vertebral veins (VVs) with the head at 0° and 90° assessed as flow reversal from its physiologic direction for a duration of >0.88 s during a short period of apnea following a normal exhalation
2. reflux in deep cerebral veins assessed as the presence of flow reversal for a duration of >0.50 s during normal breathing
3. high-resolution B-mode ultrasound evidence of proximal stenosis of the internal jugular vein (CSA < 0.3 $cm^2$)
4. flow not Doppler detectable in the IJVs or VVs despite numerous deep inspirations with the head positioned at 0° and 90°
5. reverted postural control of the main cerebral venous outflow (negative ΔCSA)

Both the careful reading and analysis of the ultrasound protocol described and applied by the proposing authors [1,2] and the negative findings of standardized ultrasound studies from other groups [4—7], raised many doubts about the ability of these criteria to provide a reliable evaluation of the cerebral venous hemodynamics. These considerations suggested to make efforts for identifying, applying and validating other ultrasound-assessable items for describing the venous hemodynamics.

FISM, a non-profit organization, is the promoter of a multicentre study, with the aim of obtaining the best response about the proposed hypothesis of a venous involvement in for people with MS worldwide. It will be possible through a study of large sample size to estimate the prevalence of venous abnormalities in MS, compared with the observed rate in normal controls and in patients affected by other neurologic diseases.

In this context, the distinctive features of the present study and previous studies comparing the current state of knowledge are as follows:

1. multicenter observational study with blinded ultrasound examination;
2. sample size of at least 1200 MS people
3. assessment of the prevalence of CCSVI and other forms of changes of venous hemodynamics in clinically isolated syndrome, relapsing-remitting, primary progressive and secondary progressive MS, using a larger sample than the one used to date.

A standardized ultrasound examination protocol was designed and implemented in a detailed training phase of the sinologist of the participating centres. The ultrasound protocol was distinguished in a basic protocol and an advanced protocol. The proposal of an advanced protocol came from the consideration that the assessment of the cerebral venous hemodynamics, both in intracranial and in extracranial pathways, does not mean only CCSVI, but it involves a global balance of the cerebral venous system (blood outflow patterns), validated measurement of valve function and a complete evaluation of the intracranial pathways and other items.

The topic of this paper is to provide some details about the advanced items of the ultrasound evaluation of the cerebral venous hemodynamics, starting from the critical evaluation of the five criteria proposed by Zamboni et al. for the diagnosis of CCSVI [1,2], with the aim of overcoming their limitations and finding the more proper items to evaluate the physiology and pathology of the cerebral venous hemodynamics.

## Advanced ultrasound protocol

The definition of a more detailed and advanced study of the venous hemodynamics started from the highlight of the limitations and pitfalls of the proposed CCSVI criteria [1,2] and continued with the proposal of an alternative method to overcome them, considering the ultrasound methodological items from the literature.

### Criterion 1

One of the main pitfalls of the criterion 1 is that the proposed temporal threshold for the jugular and vertebral reflux is validated only in other conditions, i.e. at the site of the valve leaflets of the IJV and with the Valsalva maneuver (Fig. 1), and not in other breath conditions and outside the valve level for the IJV and other veins [8,9].

Another doubtful aspect in the published studies with their description of the ultrasound protocol is the measurement of the reflux duration, because of the lack of mentioning and image documentation of the corresponding Doppler waveform.

Although breathing is a known factor affecting the venous hemodynamics, both in the neck and in the brain, there is not a validated ''breathing activation maneuver'', measurable, repeatable and reliable. Instead the Valsalva maneuver