Supervised automatic procedure to identify new lesions in brain MR longitudinal studies of patients with multiple sclerosis

Identificazione automatica controllata di nuove lesioni in studi RM encefalici longitudinali di pazienti affetti da sclerosi multipla

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Abstract

Purpose. Identification of new enhancing lesions is a major endpoint of longitudinal brain magnetic resonance (MR) studies of multiple sclerosis (MS). To date, this is a visual, time-consuming procedure. We present here a supervised automated procedure (SAP) aimed at reducing the time needed to identify new MS enhancing lesions.

Materials and methods. The SAP uses an algorithm including Cartesian coordinates of the lesions to be compared, their area and a constant (k). The procedure was validated for enhancing lesions on T1-weighted spin-echo images after intravenous administration of 0.1 mmol/kg of paramagnetic contrast agent, randomly selected from a dataset of a longitudinal MR study on ten relapsing-remitting MS patients followed for 2–5 years. During the validation session, two readers decided by consensus whether two lesions, present on the same slice of two examinations performed on subsequent dates, were the same or not. In this way, k was calibrated to obtain the same result from both visual inspection and automatic algorithm output.

Results. After evaluating of 25±5 (mean±standard deviation) lesions in each of ten different sessions with correction of k value, the k value became a stable value (0.45±0.05).

Conclusions. Once the suitable value of k was found, SAP

Riassunto

Obiettivo. L’identificazione di nuove lesioni con contrast-enhancement è un importante end-point negli studi RM encefalici longitudinali di pazienti affetti da sclerosi multipla (SM). Tale compito è a tutt’oggi realizzato mediante visualizzazione comparativa con notevole dispendio di tempo. In questo lavoro viene presentata una procedura automatica controllata (PAC) finalizzata a ridurre il tempo necessario per l’identificazione di nuove lesioni SM con contrast-enhancement.

Materiali e metodi. La PAC utilizza un algoritmo che richiede la definizione delle coordinate cartesiane delle lesioni da confrontare, della loro area e di una costante (k). Tale procedura è stata valida per un dataset di lesioni con contrast-enhancement visibili su immagini spin-echo T1-pesate ottenute dopo somministrazione endovenosa di 0.1 mmol/kg di mezzo di contrasto paramagnetico, selezionate mediante randomizzazione da uno studio longitudinale di 10 pazienti affetti da SM intermittente-remittente, seguiti nel tempo per 2–5 anni. Per la validazione della procedura due osservatori hanno deciso per consenso se due lesioni presenti nello stesso strato in due esami successivi fossero la stessa lesione o meno. In tal modo la costante k è stata calibrata fino a definirne un valore per il quale l’algoritmo era in grado di fornire automaticamente la stessa valutazione dei due osservatori.
was able to identify new enhancing lesions, avoiding visual inspection, which is usually a lengthy procedure.

**Keywords:** Magnetic resonance · Multiple sclerosis · New Gd-enhancing lesions

**Introduction**

Longitudinal trials on patients affected with multiple sclerosis (MS) are commonly performed including brain magnetic resonance (MR) imaging findings as an endpoint of the study [1–5]. MR dataset mostly consists of number and area (or volume) of hyperintense lesions on unenhanced spin-echo (SE) or fast-SE dual-echo or fluid-attenuated inversion recovery images (FLAIR) or of number and area (or volume) of enhancing lesions on T1-weighted SE images after intravenous administration of a gadolinium (Gd)-based paramagnetic contrast agent on repeated MR exams [6]. Considerable expert readers’ time is needed to obtain these measures, especially for a slice-by-slice lesion area calculation (from which the volume is easily derived), even if software has been developed to do this job in a semiautomated or totally automated manner, with large time saving [3, 7–9].

Another major MR endpoint is the monthly number of new lesions and, in particular, of new enhancing lesions [10]. In fact, enhancing lesions are considered a disease activity marker and their longitudinal fluctuation in number and area or volume are useful data regarding the natural history and evolution of MS [11, 12]. Enhancing lesions in MS reflect a blood-brain barrier impairment and active inflammation [13, 14]. They can be considered to be a predictor of the occurrence of clinical relapse [15].

The aim of this paper is to present a supervised automatic procedure (SAP) to decide whether an MS lesion is new or not on the basis of a comparison between two brain contrast-enhanced MR exams performed on different scan dates (typically, subsequent examinations).

**Materials and methods**

A longitudinal study was performed on ten relapsing–remitting MS patients using 0.5-T MR equipment (MR5000,