Abstract Our objective was to assess the inter-observer and intra-observer agreement in the interpretation of digital subtraction venography (DSV) in patients with suspected deep vein thrombosis of the upper extremity (DVTUE). Prospectively, 62 consecutive DSV studies in 54 patients with clinically suspected DVTUE were included. Hard copies were presented without demographic data or original report. All venograms were read twice, at 3-month intervals, by an interventional vascular radiologist (observer 1) and an experienced general radiologist (observer 2). Consensus reading took place in the presence of a third experienced interventional radiologist. Inter-observer and intra-observer agreement were assessed using kappa statistics. Initial reading in 62 venograms showed an inter-observer agreement of 71% (kappa 0.48). The inter-observer agreement of the second reading was 83% (kappa 0.71). The agreement with the consensus report ranged from 76 to 94%. The intra-observer agreement for the first and second observer was 94% (kappa 0.89) and 76% (kappa 0.56), respectively (p<0.01). Digital subtraction venography has moderate to excellent intra- and inter-observer agreement, suggesting that digital subtraction venography is reliable for the diagnosis of DVTUE.

Keywords Thrombosis · Upper extremity · Diagnosis · Digital subtraction venography · Observer variation

Introduction

Deep vein thrombosis of the upper extremity (DVTUE) has been reported in 40–45% of patients with a clinical suspicion, usually presenting with pain, swelling, or functional impairment of the upper extremity, and in severe cases with distended collateral veins over the shoulder girdle [1]. The DVTUE can be divided into primary and secondary thrombosis [2]. Primary thrombosis occurs spontaneously or after unusual effort [3]. Secondary thrombosis occurs mostly in relation to venous lines and/or cancer [4, 5, 6]. During the past decades the frequency of secondary thrombosis has been increasing due to more “technical” medicine, e.g. interventions, feeding lines, chemotherapy, or hemodialysis [7, 8, 9].

Contrast venography is considered the reference method for the diagnosis of DVTUE. However, it may be difficult to perform due to venous access requirements and it involves iodinated contrast agents [10]; thus, alternative methods have been pursued. Real-time ultrasonography and color duplex imaging are both useful diagnostic tools but are technically challenging in the upper thoracic aperture vessels due to the neighboring clavicle and sternum [11]. Magnetic resonance venography (MRV) has been suggested as an alternative method but is currently insufficiently proven to replace contrast venography [12, 13, 14, 15]. A development over the past 5–10 years has been the introduction of digital angiography technologies. Although this has been widely implemented, the effects on diagnostic accuracy for venography of suspected DVTUE has not been determined. As
far as we are aware, digital venography has not undergone formal evaluation of intra- and inter-observer variability.

The aim of this study was to assess the diagnostic reproducibility of digital subtraction venography in a consecutive series of 55 patients with clinically suspected deep vein thrombosis of the upper extremity.

**Materials and methods**

**Patient population**

During the period of August 1996 to May 1999, 55 consecutive patients with clinically suspected DVTUE were referred for digital subtraction venography. Written informed consent was obtained prior to venography from all patients. Two of these patients were referred twice, and 2 patients were referred a third time. Two patients with suspicion of both right and left arm vein thrombosis had a venography of both sides in the same session, which were assessed as separated venograms. The hard-copy images of 1 patient were not available due to a failure in the image processor and this patient was excluded from further analysis; hence, a total of 62 venographic studies in 54 patients were available for the study.

There were 22 men and 32 women with a mean age of 53 years (range 18–92 years). Deep vein thrombosis was initially demonstrated in 31 of 62 venograms for a prevalence of 50%. The cause of thrombosis was considered to be primary in 3 patients, whereas an underlying cause could be shown in 25 patients (malignancy, n=11; central venous catheter, n=3; malignancy and central venous catheter together, n=10; central venous line and congenital thrombophilia together, n=1). Three patients who were referred twice or a third time with a malignancy and central venous line showed recurrent thrombosis.

**Imaging technique and definition of DVTUE**

Contrast venography of the symptomatic extremity was performed using digital subtraction angiography equipment (Polytron, Siemens, Erlangen, Germany). A standardized protocol consisted of a 30-ml contrast injection in the antecubital vein, or if this was not possible a more distal forearm vein of the affected arm. No tourniquet was applied. Patients were studied with the examined arm in extension and little abduction of the upper arm to prevent self-compression of the axillary vein by soft tissues. Low osmolar nonionic contrast was used with a concentration of 300 mg iodine/l (Omnipaque, Nycomed Amersham, Oslo, Norway). All injections were performed by hand. Digital subtraction images of the brachial, axillary, subclavian, and superior caval veins were obtained at a rate of one frame per second.

One angiographic series was performed in each patient. In 3 patients one additional series was required due to difficulty in assessment or projection of the images. The images were selected for best available display of the venous system prior to transformation onto hard-copy film. The procedures were performed by a variety of radiologists, ranging from supervised senior residents to experienced vascular radiologists. An initial report was made, which was considered the true outcome, was also compared with the initial report to allow assessment of the potential influence of the dynamic series.

**Statistics**

The extent of agreement between the two radiologists (interobserver agreement) of both readings, between assessments of the individual observers (intraobserver agreement), and between the initial and consensus report was determined. Subsequently, the kappa statistic was calculated in the standard fashion [16]. The kappa statistic is defined as the observed agreement, divided by the agreement not accounted for by chance. This index has a range of +1.0 (perfect agreement) to −1.0 (total disagreement). The 95% confidence intervals were calculated [16].

The chi-squared test was used to compare the results of agreement between the two observers, with a p-value of 0.05 considered statistically significant.

**Results**

In the first reading a total of 9 of 62 venograms were considered indeterminate: in one venogram both observ-