梨花醫大誌 : 第 27 卷 第 1 號 2004
Ewha Med J Vol. 27, No. 1, 2004

Gadolinium-Enhanced 3D Fast Imaging Steady-State Procession(FISP) MR Venography in the Deep Vein Thrombosis of Low Extremities

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= 국문초록 =

하지 심부정맥혈전 진단에서 가돌리늄 조영증강 3D Fast Imaging Steady-State Procession(FISP) 자기공명정맥조영술

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유 정 현 · 서 정 수

연구목적 : 하지정맥의 심부혈전 진단에 조영증강 자기공명정맥촬영술을 사용하고, 도플러초음파검사와 비교하여 진단적 가치의 우수성을 나타내고자 한다.

대상 및 방법 : 도플러초음파검사상 심부정맥혈전이 의심된 30명의 환자에서 가돌리늄 조영증강 MR 하지정맥술을 시행하였다. MR기법은 삼차원 fast image steady-state procession(FISP)을 사용하였다. 심부정맥혈전의 진단은 조영증강된 혈관내의 신호강도결핍을 보이는 경우로 하였다. 해부학적 혈관의 분포에 따라 혈관들은 각각 절편(segment)에 따라 외장골정맥, 총대퇴정맥, 표재대퇴정맥, 심부대퇴정맥, 슬와정맥, 전경골정맥, 후경골정맥, 비골정맥, 발목정맥으로 분류하였다. 도플러초음파결과와 비교하여 각각에 대한 통계적 유의성검증을 하였다.

결 과 : 조영증강 자기공영 정맥조영술은 정상적으로 조영증강되는 혈관과 대조되는 신호강도결핍의 심부정맥혈전을 잘 나타내었다. 30명환자의 40예의 하지에서 각각의 절편에 따라 400절편으로 분류하였을때, 심부정맥혈전은 111절편(27.75%)에서 관찰되었고 도플러초음파상에서는 77(19.25%)에서 관찰되었다. 이중 75절편(17.75%)에서 자기공명영상과 도플러초음파 검사에서 모두 혈전을 나타내었다. Mc-Nemar's chi-squere검사상 자기공명정맥조영술이 도플러초음파 검사에 비해 통계적으로 유의성이 있게 우수함을 나타내었다(Table 1. χ^2=25.13, p=0.001). 심부혈전의 위치는 표재성대퇴정맥이 가장 많았고, 총대퇴정맥, 슬와정맥, 후경정맥의 순이었다. 자기공명정맥조영술은 외장골정맥, 발목정맥을 관찰하는데 도플러초음파보다 우수하였고, McNemar's Chi-squere 검사상 외장골정맥(χ^2=8.00, p<0.005), 발목정맥(χ^2=5.00, p<0.05), 후경정맥(χ^2=4.00, p<0.05)에서 통계적 유의성을 나타내었다(p<0.05) (Table 2).

결 론 : 조영증강 자기공명정맥술은 하지정맥 심부정맥혈전의 진단에서 도플러초음파검사보다 통계적으로 유의하게 우수하였다. 특히, 혈전의 골반강 침범과 발목정맥 및 심부calf 정맥의 혈전진단은 통계적으로 유의하게 우수하였다.

중심 단어 : Deep Vein Thrombosis · Venography · MR.

Recently, use of paramagnetic contrast agents has been found to improve the quality of MR angiograms in the abdomen and periphery[1-12]. Advantages of use of contrast agents include less dependence on flow pattern to establish signal intensity. The T1 shortening effects of contrast media in the gadolinium enhanced blood result in transient increased signal intensity in the vascular structure. Conventional MR venography using Time of Flight (TOF) technique can be susceptible to pulsatility, saturation effects, and spin dephasing when laminar flow is disturbed, all of which can limit the intravascular uniformity. Gadolinium enhanced MR venography, however, can be minimized or overcome completely the limitation of TOF technique[1-6].

In the diagnosis of the deep vein thrombosis (DVT), gadolinium enhanced MR venography could easily detect DVT as signal voided filling defects compared with enhancing normal vessel[13-15]. Doppler ultrasonography (US) has been usually used for the detection and diagnosis of DVT because it is simple and noninvasive[6-18]. But it is true that Doppler US has limitations for the evaluation of swollen legs and deep pelvic cavity extension[19-21].

To the best of our knowledge, this is the first report about the comparative study between the gadolinium enhanced MR venography and Doppler US in the diagnosis of DVT of low extremity. In our prospective comparative study, we will demonstrate of DVT of low extremity using the gadolinium enhanced MR venography and to decide the superiority of the technique to Doppler US in the detection of DVT.

Materials and Methods

Gadolinium enhanced MR venography was performed in 30 patients undergoing evaluation of DVT of low extremity. The patients were selected from those who were performed Doppler US and detected DVT of low extremities and gave their consent to undergo MR venography. The age range of the patients was 33-69years and the male : female ratio was 19 : 11. MR venography wase performed within 1week after Doppler US in each patient. MR imaging was performed with a 1.5-T MR imaging system (Magneton Vision : Siemens Medical Systems, Erlanger, Germany). The body array coil was used for all patients. Venous route was achieved with an 18-20 gauge needle in the antecubital fossa or forearm. For contrast enhancement, gadopentetate dimeglumine (Megnevist ; Schering) was administered by hand injection at a dose of approximately 0.1mmol/kg for each injection.

The 3D fast imaging steady-state procession (FISP) sequence was used in all patients. The parameters of 3D FISP were as follows : TR/TE, 5/2msec ; flip angle, 15℃ ; field of view, 380-400mm ; matrix size, 160×256 ; effective slide thickness, 3mm. Fat suppression was performed to eliminate background signal intensity and to improve vessel conspicuity. The image was completed with five contiguous data acquisitions and no time elapsed between acquisitions. The imaging time per measurement was obtained from 25-40sec due to the maximum resolution of the vein contrast. A maximun-intensity-projection (MIP) algorithm was used for image reconstruction around the coronal orientation.

Evaluation of MR venograms and data analysis : Enhanced MR venography and Doppler US were interpreted in a prospective fashion. For analysis, the vessels were divided into following segments : external iliac vein (EIV), common femoral vein (CFV), superficial femoral vein (SFV), deep femoral vein (DFV), popliteal vein (POPV), anterior tibial vein (ATV), posterior tibial vein (PTV), peroneal vein (PERV), and ankle vein (AKV). The vessels were classified as normal or thrombosed. The diagnosis of DVT was based on the signal voided filling defects of the enhanced vessel. The data/result of DVT was compared with those of Doppler US according to the vascular segments. To determine statistical significances whether enhanced MR venography is superior to the Doppler ultrasonography or not in the detection of DVT of low extremity, McNemar's Chi-square test was used.

Results

Gadolinium contrast enhanced MR venography well demonstrated venous thrombosis as signal voided filling defect contrast to the enhanced vein (Fig. 1-3).

In the 400 segments of 40 low extremities of 30 patients including both extremities of 10 patients, 111 seg-

ments (27.75%) revealed positive MR venograms which is superior to the positive results of Doppler US of 77 segments (19.25%). Seventy one segments revealed thrombosis in the both of two studies. While Doppler US depicted 6 thrombosis not seen at MR venography, MR venography depicted thrombosis in 40 segments not displaced at Doppler US. Results of the McNemar's Chi-squere test revealed better results of MR venography in order Doppler US with statistical significance (χ^2= 25.13, p<0.001) (Table 1).

Fig. 1. Gadolinium enhanced MR venography of low extremity well depicted deep vein thrombosis of iliac vein as signal voided filling defects. Gadolinium enhanced MR venography was excellent in the evaluation of deep pelvic cavity thrombosis and central extents of thrombosis.

The predilection sites of the DVT of low extremity were SFV (25), CFV (22), POPL (20), and PTV (14) according to the orders. In the segmental evaluations, thrombosis of POPL (17/20, 85%), SFV (20/25, 80%), and CFV (15/22, 68%) was well detected on both of studies. MR was superior to the Doppler US in the evaluation of CIV (4/4 vs. 0/4), EIV (11/11 vs. 3/11), PTV (14/14 vs. 10/14) and ANKLE (8/8 vs. 0/8), in which EIV (χ^2=8.00, p<0.005), ANKLE (χ^2=5.00, p<0.05) and PTV (χ^2=4.00, p<0.05) show statistical significance (Table 2).

As compared with the results between the Doppler US and MR, MR imaging documented central and pelvic extent and correct distribution of thrombus better than

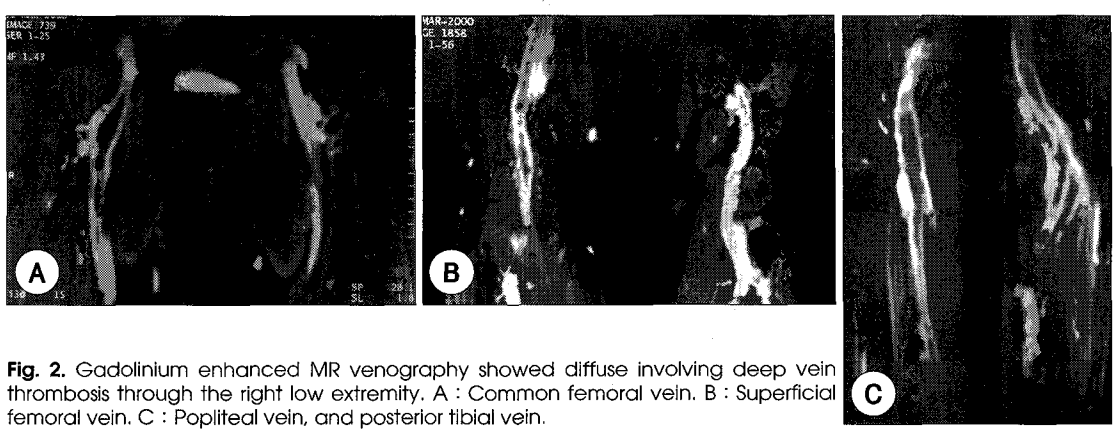

Fig. 2. Gadolinium enhanced MR venography showed diffuse involving deep vein thrombosis through the right low extremity. A : Common femoral vein. B : Superficial femoral vein. C : Popliteal vein, and posterior tibial vein.

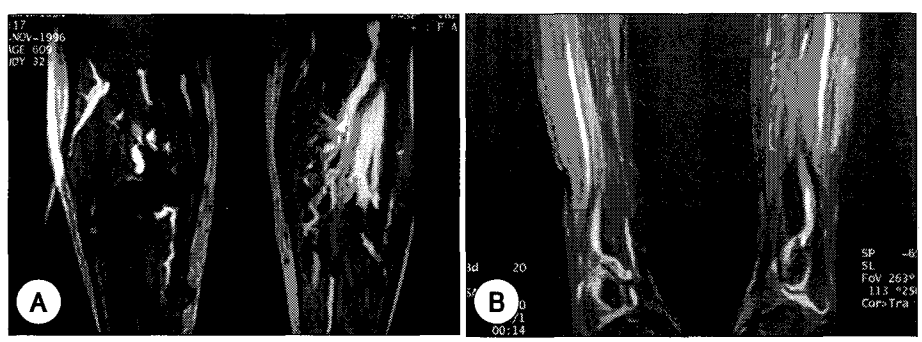

Fig. 3. Gadolinium enhanced MR venography was superior to the Doppler ultrasonography in the detection of thrombosis of calf vein (A) and small ankle vein (B).

Table 1. The Results of Deep Vein Thrombosis of low extremity compared with enhanced MR venography and Doppler Ultrasonography

DVT		US		Total	McNemar's χ^2
		YES	NO		
MR	Yes	71(17.75)	40(10.00)	111(27.75)	χ^2=25.13 (p=0.001)
	No	6(1.50)	283(70.75)	289(72.25)	
Total		77(19.25)	323(80.75)	400(100.00)	

Table 2. Segmental distributions of the Deep Vein Thrombosis in low extremity

	MR+US(Yes)	MR(Yes)	US(Yes)	MR+US(No)	Total	McNemar's χ^2
CIV†	0	4	0	36	40	-
EIV	3	8	0	29	40	8.00**
CFV	15	4	3	18	40	0.14
SFV	20	4	1	15	40	1.80
DFV	2	4	1	33	40	1.80
POPL	17	2	1	20	40	0.33
PTV	10	4	0	26	40	4.00*
ATV	1	3	0	36	40	3.00
PERO†	0	2	0	38	40	-
ANKLE	3	5	0	32	40	5.00*
Total	71	40	6	283	400	

†: McNemar's test could not be calculated that the numbers of cell with zero sample were above 2 cells in 2×2 table

* : $p<0.05$, ** : $p<0.005$

Doppler US (Fig. 1, Table 2). And MR evaluations of small vessels or branches of ankle or deep calf are superior to those of Doppler US (Fig. 3). MR imaging also well demonstrated ancillary abnormalities such as varicose vein, collateral vessels, leg edema, and underlying bone disease.

Discussion

The principle of gadolinium enhanced MR angiography is vascular images based on T1 shortening effects[11-12]. One of the merits of this study is minimizing flow artifacts and saturation effects that may degrade traditional unenhanced two-dimensional TOF imaging techniques[1-6]. Gadolinium enhanced MR angiography has been usually used in the arterial evaluation of cerebral and pulmonary artery and abdominal aorta. Recently, gadolinium enhanced MR angiography has been applied in venous system with good results. The application of MR venography was excellent in documenting enhancing normal venous structure and it could be used in the various venous disease such as varicose vein or vein thrombosis.

Gadolinium enhanced MR venography in the DVT has been studies in recent years that could be easily depicted thrombus as signal voided filling defects contrast enhancing vascular structure and that was reported the superiority to the other MR techniques[13-15].

For the diagnosis of DVT of low extremity, Doppler US has been used as a screening method because it is easy and noninvasive. However, in the evaluation of the pelvic cavity and swollen calf vein, there have been limitations in the diagnosis of deep vein thrombosis.

There have been several reports about the correlation or comparison with the Doppler US and MR venography in the detection of DVT, however, in which the MR technique was based on unenhancing MR technique. We couldn't find the report of comparison study between the gadolinium enhanced MR venography and Doppler US in the detection of DVT of low extremity. To the best of

our knoeledge, this study may be a first report about the prospective and comparative study between the gadolinium enhanced MR venography and Doppler US.

The preselections of the patients from those who were diagnosed deep vein thrombosis with Doppler US were a limitation of this study and undertaken to examine the feasibility of the MR imaging. However, we tried to overcome the limitation for the segmental careful evaluations of Doppler US and MR imaging, prospectively.

Our results showed good image demonstration of the low extremity venous anatomy and well depicted signal voided DVT within the enhancing vessel. The detection rate of DVT was superior to that of Doppler US with stastatical significance (χ^2=25.13, p<0.001) (Table 1).

As compared with Doppler US, the important merits of the gadolinium enhanced MR venography allow for good resolution of the deep pelvic cavity extension (χ^2 =8.00, p<005) and the very small vessels of ankle (χ^2 =5.00, p<0.05) and deep calf vein (χ^2=4.00, p<0.05) thrombosis with stastatical significance (Table 2).

And, the MR venography was more correct in the evaluation of extents of DVT than Doppler US which was possibly from the MR venography to three dimensional (3D) image and reconstructive image. Multiplanar reconstructions of the 3D MR acquisition were very useful in the tortuous vascular anatomy and anatomical demonstration of the extent and distribution of the thrombosis.

In addition, MR venography could be gained additional informations about the patients such as varicosities, bony lesion, and soft tissue evaluation.

The single scan time of gadolinium enhanced MR venography was very short in about 20−25sec and total practical time including image process was not longer than Doppler ultrasonography.

In a point of disadvantage of the Gadolinium enhanced MR venography for the Doppler US, it may be invasive study for contrast injection and expensive study and then may be a limitation as initial screening study. However, when the initial screening studies are unavailable or unsatisfactory or if there is a suspicion for pelvic thrombosis, gadolinium enhanced MR venography would be successful and satisfactory studies.

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