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Islam Abd El Hamid Ragab Kheira
Diagnostic Radiology, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt, salomnty@gmail.com

Mostafa Ali Motawea
Diagnostic Radiology, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt

Mahmoud Ibrahim El Shamy
Diagnostic Radiology, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt

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ORIGINAL ARTICLE

Magnetic Resonance Lymphangiography in Lower Limb Lymphedema

Islam A. R. Kheira *, Mostafa A. Motawea, Mahmoud I. El-Shamy

Department of Diagnostic Radiology, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt

Abstract

Background: ***Magnetic Resonance Lymphangiography (MRL) represents a pivotal advancement in the diagnostic imaging of lower limb lymphedema, offering detailed insights into lymphatic system abnormalities.***

Aim: ***To evaluate the feasibility and efficacy of high-resolution MRL using gadodiamide in patients with primary and secondary lower extremity lymphedema.***

Methods: ***This prospective study Conducted at Al-Azhar University Hospitals examined 20 patients who underwent MRL, adhering to strict inclusion and exclusion criteria to ensure the validity of findings. The imaging protocol entailed a meticulous approach, using a 1.5-Tesla MRI unit and a contrast-enhanced technique to visualize lymphatic and vascular structures optimally. This method facilitated classifying lymphatic drainage patterns into five distinct types, providing crucial information for surgical planning and therapeutic strategies.***

Results: ***We found that the prevalence of primary lymphedema was 45% of cases, with secondary causes mainly attributed to surgical interventions and trauma. A notable finding was the identification of dermal backflow in the distal leg (Pattern I) in 35% of cases, indicating advanced lymphatic dysfunction. Moreover, the study highlighted MRL's technical feasibility and safety, emphasizing its minimal invasiveness and potential as a superior diagnostic tool for lymphedema assessment. The mean time for detecting dilated lymphatic vessels was approximately 24 minutes, with a mean maximum diameter of 3.53 mm, underscoring the technique's efficacy in delineating lymphatic pathology.***

Conclusion: ***This study validates the utility of MR lymphangiography as a morphologically and functionally superior, minimally invasive imaging modality. It underscores its significance in mapping the lymphatic system and staging lymphedema, paving the way for targeted therapeutic interventions. MRL emerges as a promising diagnostic tool, offering significant benefits over traditional methods regarding safety, accuracy, and comprehensive assessment capabilities.***

Keywords: Magnetic Resonance Lymphangiography; Lower Limb Lymphedema; Diagnostic Imaging; Lymphatic System; Gadodiamide

1. Introduction

Lymphedema, a chronic condition characterized by the accumulation of lymphatic fluid, leads to significant swelling and potential skin and tissue alterations. This condition arises from an overload of protein-rich lymphatic fluid in the interstitial and fibro-adipose tissues, overwhelming the lymphatic system's transport capacity .[1] Lymphedema can manifest throughout the body, affecting the limbs, genitals, face, neck, chest wall, and oral cavity .[2] Notably, chronic lower limb lymphedema presents as a severe ailment, challenging to both diagnose and treat despite medical advancements .[3] Its symptoms encompass swelling, skin modifications, discomfort, limited mobility, and nonpitting edema .[4]

Lymphedema is categorized into primary, often due to genetic abnormalities affecting lymphatic functions, and secondary, resulting from diseases, infections, or medical interventions that damage the lymphatic system.[5] Diagnosis typically involves clinical evaluation, comparing limb measurements to identify discrepancies. Although lymphatic system imaging is not always essential for diagnosis, it aids in differentiating lymphedema from other edema causes .[6]

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* Corresponding author at: Diagnostic Radiology, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt.
E-mail address: salomnty@gmail.com (I. A. R. Kheira).

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Prompt intervention is crucial for preventing functional decline and quality of life deterioration .[7] Innovations in super microsurgery have enabled the creation of lymphatic venous anastomoses to divert lymph fluid into the venous system, thereby mitigating symptoms and reducing limb size .[8] Accurate lymphatic visualization, including pre-surgical lymphatic mapping, is vital for early diagnosis and treatment planning .[9] Previously, direct lymphography and technetium-99m lymphoscintigraphy were standard, offering detailed anatomical or functional insights, respectively, but were invasive and involved radiation exposure .[3]. MRI lymphangiography is a superior choice, providing comprehensive functional and anatomical information essential for microvascular surgery planning in lymphedema cases. This technique is distinguished by its safety, minimal invasiveness, and efficiency in evaluating lymphedema's extent, lymphatic vessels, lymph nodes, venous structures, and drainage patterns .[10]

This study's purpose was to evaluate the feasibility of high-resolution (HR) MR lymphangiography with intracutaneous injection of gadodiamide for the visualization of lymphatic vessels in patients with primary and secondary lower extremity lymphedema.

2. Patients and methods

This prospective cross-sectional analysis was conducted at the Diagnostic Radiology Department of Al-Azhar University Hospitals from August 2022 to December 2023. It involved 20 patients diagnosed with lower extremity lymphedema who underwent MR lymphangiography. Inclusion criteria were patients with lymphedema affecting one or two lower extremities who agreed to participate. Exclusion criteria included MRI contraindications, renal insufficiency, known contrast agent allergies, or refusal to participate.

Ethical approval was obtained from the local ethical committee, ensuring patient confidentiality and the use of collected data solely for scientific purposes. Patients were informed about the study's benefits and potential risks and provided oral consent before enrollment.

The patient evaluation comprised history taking (personal details, current complaints, previous health issues, and medication use), clinical examination to rule out systemic causes of lymphedema, and local examination of the affected limbs. Lymphedema was staged according to the Foeldi and Foeldi classification.

The MR lymphangiography technique involved using a 1.5-Tesla MRI unit with appropriate coils for extensive anatomical coverage. Patients were positioned supine with their legs elevated for optimal imaging. For patient comfort, a small gauge needle was used for subcutaneous injection of a contrast agent and lidocaine. The imaging protocol included a precontrast sequence to enhance contrast sensitivity, followed by postcontrast imaging at various intervals to assess lymphedema and lymphatic pathways.

Image analysis was performed on a 3D workstation to visualize lymphatic and vascular structures, aiding in surgical planning. The study classified lymphatic pathways into five patterns based on their appearance in MR lymphangiography, providing insights into the condition's severity and distribution. Pattern I is characterized by numerous small cutaneous lymphatic vessels showing progressive dispersion of contrast material into the surrounding soft tissues, a condition known as dermal backflow, predominantly seen in the distal leg, along with sparse dilated lymphatic collectors in the proximal leg. Pattern II features prominently enhanced lymphatic vessels in a radiating pattern around the distal leg, converging at the medial knee before ascending towards the thigh. Pattern III presents with barely enhanced and dilated lymphatic vessels with an interrupted trajectory along the medial aspect of the entire lower extremity. Pattern IV is distinguished by clusters of ecstatic and markedly enhanced lymphatic vessels, more prevalent on the thigh's medial side than the lateral. Lastly, Pattern V describes dilated and opacified lymphatic vessels extending from the distal leg to the inguinal nodes, with minimal branching observed along their path .[11]

Statistical analysis: Data were fed to the computer and analyzed using IBM SPSS software package version 25.0 (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp). Qualitative data were described using numbers and percentages. The Shapiro-Wilk test was used to verify the normality of the distribution. Quantitative data were described using range (minimum and maximum), mean, standard deviation, and median. The significance of the obtained results was judged at the 5% level.

3. Results

Out of 20 patients included in this study, there were 12 (60%) males and 8 (40%) females with male to female ratio was 1.5:1. The age of patients ranged between 13 years to 68 years with mean age was 38.8± 12.1 years. Most of patients (70%) were between the age group of 31-60 years.

Regarding causes of lymphedema, Primary lymphedema was the most frequents found in 9 (45%) followed by lymphedema after surgery in 7 (35%) then traumatic causes that accounted for 4

(20%) cases. According to side of lymphedema, 12 cases (60%) had bilateral edema while unilateral edema was found in 40% cases. Edema extended below knee in 12 (60%) cases, mid-thigh in 3 (15%) cases, at the ankle in 2 (10%) cases, up to scrotum in 2 (10%) cases, and at upper thigh in one (5%) case. Regarding pattern of lymphatic drainage, the most frequent pattern of drainage found was pattern I (35%) that indicates presence of dermal backflow seen in the distal leg, in addition to scanty dilated lymphatic collectors that were depicted in the proximal leg. Pattern II was reported in 6 (30%) cases indicates enhanced lymphatic vessels in a radiating fashion seen in the distal leg, they clustered at the inner (medial) aspect of the knee and then ascended to the thigh. Pattern III was reported in 4 (20%) cases indicates Barely enhanced & dilated lymphatic vessels but with interrupted course along the inner (medial) aspect of the entire lower extremity. While Pattern IV was reported in 3 (15%) cases indicates presence of aggregates of ecstatic and obviously enhanced lymphatic vessels that were seen more in the inner (medial) than in the outer (lateral) aspects of the thigh as shown in Table 1.

It was found that most cases (75%) had dilated lymphatic vessels. Out of those cases, the dilated vessels was unilateral in 10 (50%) cases and bilateral in 5 (25%) cases. Regarding level of dilatation, more than half cases (55%) had dilated vessels below knee. The mean time needed for detecting dilated lymphatic vessels was 24.0± 6.6 minutes and ranged from 15 minutes to 35 minutes. The mean maximum diameter of lymphatic vessels was 3.53± 1.3 mm and ranged from 2 mm to 5 mm as shown in Table 2

The mean delay drainage scoring was 2.15± 0.81 and ranged from zero to 3. Score 2 was the commonest among the studied patients (50%) as shown in Table 3.

Detected pelvic lymph node was found in 12 (60%) cases. interstitial enhancement was reported in 13 (65%) cases. obstruction was noticed in 6 (30%) cases, collateral vessels was found in 13 (65%) cases while dermal back flow was found in 12 (60%) cases as shown in Table 4.

Regarding treatment, eight cases (40%) received conservative therapy, 8 cases (40%) received physiological techniques while 4 (20%) cases received reductive technique (excision) as shown in Table 5.

Table 1. Causes of lymphedema among the studied patients

		STUDIED PATIENTS (N= 20)	
		N	%
CAUSES OF LYMPHEDEMA	Primary	9	45.0%
	After surgery	7	35.0%
	Trauma	4	20.0%
SIDE OF EDEMA	Unilateral	8	40.0%
	Bilateral	12	60.0%
EXTENSION OF EDEMA	At the ankle	2	10.0%
	Below knee	12	60.0%
	Mid-thigh	3	15.0%
	Up to scrotum	2	10.0%
	Upper thigh	1	5.0%
PATTERN OF LYMPHATIC DRAINAGE	I	7	35.0%
	II	6	30.0%
	III	4	20.0%
	IV	3	15.0%

Table 2. Data related to dilated lymphatic vessels among the studied patients.

		STUDIED PATIENTS (N= 20)	
		N	%
DILATED LYMPHATIC VESSELS	No	5	25.0%
	Yes	15	75.0%
SIDE OF LYMPHATIC VESSELS DILATATION (=24)	Unilateral	10	50.0%
	Bilateral	5	25.0%
LEVEL OF DILATATION (=24)	Below knee	11	55.0%
	Mid-thigh	1	5.0%
	Upper thigh	2	10.0%
	Up to scrotum	1	5.0%
TIME OF DETECTING DILATED LYMPHATIC VESSELS (MIN.)	Mean± SD	24.0± 6.6	
	Median	25.0	
	Range	15 – 35	
MAXIMUM DIAMETER OF LYMPHATIC VESSELS (MM)	Mean± SD	3.53± 1.3	
	Median	3.0	
	Range	2 – 5	

Table 3. Delay drainage scoring among the studied patients.

		STUDIED PATIENTS (N= 20)	
		N	%
DELAY DRAINAGE SCORING	0	1	5.0%
	1	2	10.0%
	2	10	50.0%
	3	7	35.0%
DELAY DRAINAGE SCORING	Mean± SD	2.15± 0.81	
	Median	2.0	
	Range	0 – 3	

Table 4. Other MRI findings among the studied patients.

		STUDIED PATIENTS (N= 20)	
		N	%
DETECTED PELVIC LYMPH NODE	No	8	40.0%
	Yes	12	60.0%
INTERSTITIAL ENHANCEMENT	No	7	35.0%
	Yes	13	65.0%
OBSTRUCTION	No	14	70.0%
	Yes	6	30.0%
COLLATERAL VESSELS	No	7	35.0%
	Yes	13	65.0%
DERMAL BACK FLOW	No	8	40.0%
	Yes	12	60.0%

Table 5. Treatment among the studied patients.

		STUDIED PATIENTS (N= 20)	
		N	%
TREATMENT	Conservative therapy	8	40.0%
	Physiological techniques	8	40.0%
	Reductive technique (Excision)	4	20.0%

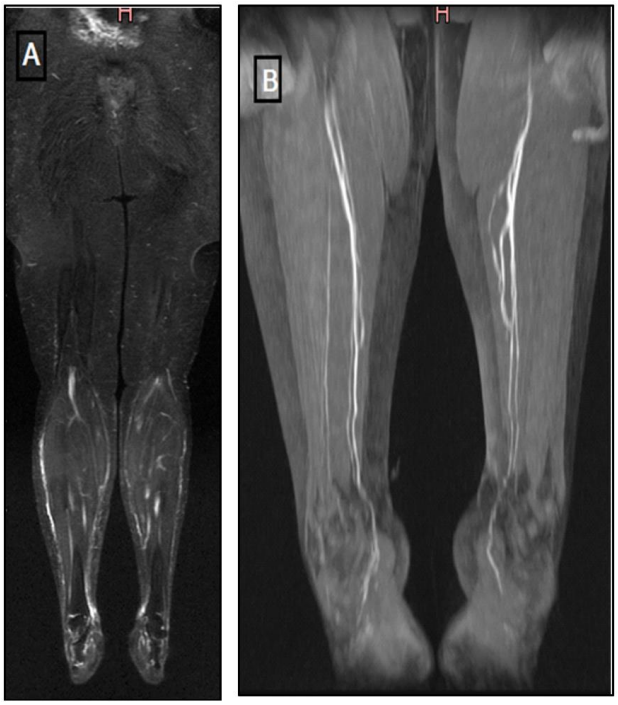

Figure 1. (A) Coronal MRI STIR shows bilateral mild edema more at right side. (B) Cronal MRI post-contrast T1 fat supression shows dilated lymphatic channels at right side and faint dilated lymphatic channels at left side.

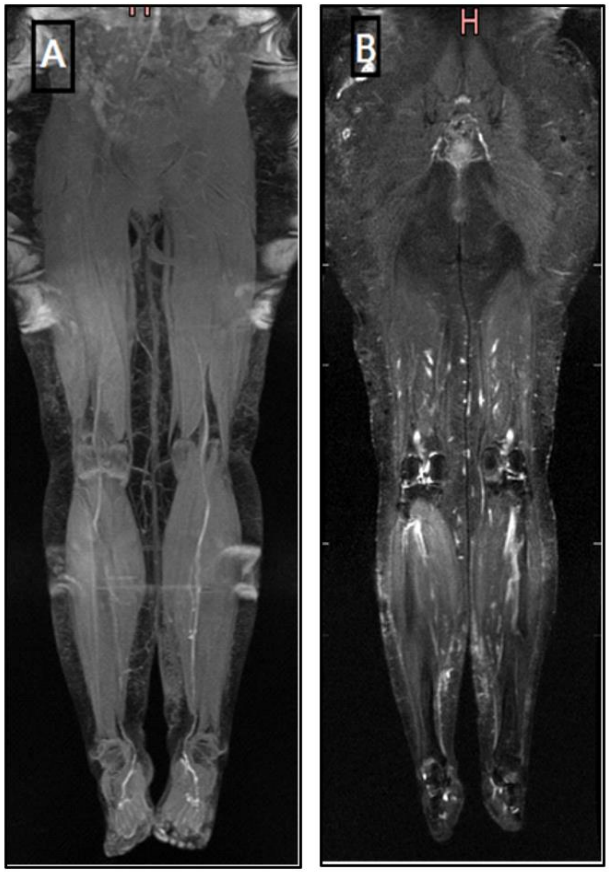

Figure 2. (A) Coronal MRI post-contrast T1 fat suppresion shows flow lymphatics are depicted within the dermal backflow assuming faint honeycombing appearance at left side. (B) Coronal STIR MRI shows bilateral asymmetrical medial legs subcutaneous edema more prominent at left side.

4. Discussion

Magnetic Resonance Lymphangiography (MRL) has recently been recognized as a groundbreaking approach for diagnosing lymphatic disorders. It effectively identifies abnormal lymphatic channels and related complications by subcutaneously administering widely accepted contrast materials.[11] The primary objective of this trial was to explore the potential of high-resolution MR lymphangiography, which employs intracutaneous injections of gadodiamide, to accurately image lymphatic vessels in individuals with primary and secondary lymphedema in the lower extremities.

The demographic breakdown of the study participants included 60% males (12 out of 20) and 40% females (8 out of 20), yielding a male-to-female ratio of 1.5:1. Participant ages ranged from 13 to 72, with the average age being 38.8±12.1 years. A significant majority, 70%, of the participants fell within the 31-- to 60-year age group.

These findings paralleled those of Mahmoud et al.[12] who also evaluated the efficacy of MRI lymphangiography in identifying non-vascular causes of lower limb swelling to assist in selecting appropriate treatment options. Their research indicated that patient ages varied from 7 to 77 years, with an average age of 33. A substantial number of their patients, 40.7%, were between 20 and 40 years old, with a distribution of 55.6% males versus 44.4% females.

Concerning the causes of lymphedema observed in our study, primary lymphedema was the most prevalent, found in 45% of cases, followed by lymphedema resulting from surgical procedures (35%) and lymphedema due to trauma (20%). These observations agreed with the distribution of lymphedema causes reported by Mahmoud et al.[12].

Our analysis further revealed that 60% of cases had bilateral edema, while 40% had unilateral edema. The distribution of oedema's extent varied, with 60% below the knee, 15% at mid-thigh, 10% at the ankle, 10% up to the scrotum, and 5% at the upper thigh. These insights into lymphatic drainage patterns and the prevalence of dilated lymphatic vessels were supported by data from other researchers, such as Baz et al. [11], who found that regarding the Pattern of lymphatic drainage, the most frequent Pattern of drainage was Pattern I 53.84%. Pattern II was reported in 26.92% of cases. Pattern III was reported in 7.69% of cases, while Pattern IV was reported in 3.84%. Also, our results were consistent with Cellina et al.[13], who aimed to assess the role of non-contrast MR lymphography

(NCMLR) for the classification and characterization of secondary lower limb lymphedema (LE). They found that regarding the Pattern of lymphatic drainage, Pattern I was in 22 patients (44%), Pattern II was in 12 (24%), and Pattern III was in the remaining 16 patients (32%).

Contrary to our findings, Zhou et al.[14] conducted a study to evaluate the efficacy of MR lymphangiography (MRL) for lower extremity lymphedema (LEL). They identified four distinct patterns of lymphatic drainage: type I involved either a single or a few mildly dilated lymphatic vessels (less than 5); type II consisted of multiple moderately to severely dilated vessels; type III comprised a large number of dilated vessels accompanied by collateral dermal backflow; and type IV featured a significant number of dilated vessels along with honeycomb-like structures. They documented the prevalence of these drainage patterns as follows: type I at 25% (16/64), type II at 45.31% (29/64), type III at 17.19% (11/64), and type IV at 12.5% (8/64).

Additionally, Arrivé et al.[15] explored the clinical stages of lymphedema, finding that stage I was present in 85 lower limbs (45%), stage II in 78 limbs (42%), and stage III in 24 limbs (13%).

Regarding treatment strategies, our study noted that 40% of cases received conservative therapy, another 40% underwent physiological techniques, and 20% were treated with reductive techniques (excision). This distribution of treatment modalities was in line with the findings of Mahmoud et al.[12], who found that regarding treatment, eight cases (29.6%) received conservative therapy, 16 (59.25%) received physiological techniques (LVA ± VLNT), and 3 (11.1%) cases received reductive techniques (excision).

4. Conclusion

The study revealed that MR lymphangiography is safe, technically feasible, and can become a diagnostic imaging tool for patients with primary and secondary lymphedema. It also found that MRL is a promising morphological and functional minimally invasive imaging modality used for mapping the lymphatic system and staging primary and secondary lymphedema.

Disclosure

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Authorship

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Conflicts of interest

There are no conflicts of interest.

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