Lymphangiography: A Nearly Lost But Necessary Technique For Potential Lymphatic Intervention
Chylous Leaks: The New Frontier For Interventional Radiologists

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Introduction

Lymphatic System-Structure
Reverse tree
Trunk – Thoracic duct
Branches are 3 Lymphatic Systems
- Peripheral Lymphatic System
- Liver
- Intestine

Lymphatic System-Flows
Reverse tree
Trunk – Thoracic duct
Branches are 3 Lymphatic Systems
- Peripheral Lymphatic System
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Lymphatic System Imaging
- Intralymphatic Lymphangiogram
- Facilitate Interventions
- Contrast Enhanced MR Lymphangiogram
- Diagnosis

Traditional Lymph Flow Imaging Techniques
PEDAL LYMPHANGIOGRAM  PEDAL LYMPHOSCINTIGRAPHY

Background/History
Central lymphatic flow physiology was extensively studied in up to the 1970s.

40 years of Hiatus!
- Absence of lymphatic imaging methods
- Absence of interventional techniques

Intranodal Lymphangiogram

24-27 G spinal needle


Shunt to Vein


Intranodal Lymphangiogram

Upstream Access


Contrast Enhanced MR Lymphangiogram

Intranodal injection
Combined MR and Fluoroscopy Machine
XMR
>100 cases performed

>100 cases performed
MR Lymphangiogram

MR Lymphangiogram

Idiopathic Chylothorax

Contrast Enhanced MR Lymphangiogram

Thoracic Duct Embolization

Constantine Cope first described minimally invasive lymphatic intervention

Therapeutic Approaches to Lymphatic Flow Disorders

Therapeutic Approaches to Lymphatic Flow Disorders

Thoracic Duct Embolization

Constantine Cope first described minimally invasive lymphatic intervention

Therapeutic Approaches to Lymphatic Flow Disorders

Chylothorax

Plastic Bronchitis

Pulmonary Lymphangiomatosis

Chyleus Anemia

Auricles

Protein Losing Enteropathy

Liver Lymphoma

Congenital Lymphedema

Chylothorax

Therapeutic Approaches to Lymphatic Flow Disorders

Liver Lymphatic Embolization

Thoracic Duct Externalization

Therapeutic Approaches to Lymphatic Flow Disorders

Chylothorax

Therapeutic Approaches to Lymphatic Flow Disorders

Liver Lymphatic Embolization

Thoracic Duct Externalization

Therapeutic Approaches to Lymphatic Flow Disorders

Thoracic Duct Embolization

Treat Chylothorax

• Minimally invasive alternative to Thoracic Duct Ligation

Rational

• Lymphangiogram

• Identification of the leak

• Minimally invasive

• Low mortality, morbidity
Intranodal Lymphangiogram

Thoracic Duct Access
- Access duct as soon as you see contrast
- Peripheral duct
- Fast “stubbing” movement
- Can go through “everything”

TD Injection

Embolization
- Microcoils
  - Nester 0.018
- Liquid embolic agent
  - Glue - n-Butyl Cyanoacrylate (n-BCA)

Coil Deployment

Glue injection
Traumatic Chylothorax Clinical Success

The overall (intent to treat) success rate was

- 77/109 (71%)

The overall success-attempted interventions

- 77/88 (88%)

Itkin et al JTCVS 2010

Traumatic Chylothorax Clinical Success-Intranodal Lymphangiogram

55 adult patients over the last two years

53/55 (96%) successfully treated with TDE

* (unpublished data)

Overall >400 cases

60 cases post unsuccessful TD ligation

Embolization

55 adult patients over the last two years

53/55 (96%) successfully treated with TDE

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Overall >400 cases

60 cases post unsuccessful TD ligation

Pulmonary Lymphatic Perfusion Syndrome (PLPS)

TD Flow Components

Pulmonary Lymphatic Perfusion Syndrome (PLPS)-aka Lymphatic Reflux

Pulmonary Lymphatic Perfusion Syndrome

Plastic Bronchitis

Formation of large gelatinous or rigid branching airway casts
Contrast Enhanced MR Lymphangiogram

Thoracic Duct Injection

Bronchoscopy TD Injection Methylene Blue Plastic Bronchitis

Embolization-Lipiodol

MR Lymphangiogram

TD Injection
Retrograde Access

TD injection with MB

Covered Stent

Plastic Bronchitis Embolization - Outcome

18 Patients with PB
16 demonstrated pulmonary lymphatic perfusion
15/16 (94%) - significant improvement of their symptoms

Lymphatic Anomalies (aka Lymphangiomatosis)

1. Generalized Lymphatic Anomaly
2. Gorham Disease
3. Kaposiform Lymphangiomatosis

Pulmonary Involvement (aka Pulmonary Lymphangiomatosis)

Pulmonary Lymphangiomatosis

- Lymphangiomas are benign, cystic, focal areas of lymphatic proliferation that can occur in any part of the body containing lymphatics
- Respiratory failure
- Unknown etiology
Lymphatic Anomaly – Kaposiform Lymphangiomatosis

March 2015 on Sirolimus

Neonatal chylothorax


Follow up

07/2015 09/2015
Liver Lymphatic System

Ernst Starling (1894)
- First described liver lymphangiogram flow
- Normal liver lymph contributes 30-40% of the flow to the TD
- Estimate 500-800 ml/day

40% of total body proteins returned to blood circulation through TD

Liver Congestion

Congested liver (cirrhosis, CHF)
- Flow increases 10 folds
- 10-20 liters a day in adult

Original theory of liver ascites
- Leakage of the lymph in the peritoneal cavity

Liver Lymphangiogram

First described in 1962 Moreno et al

Few publications
- Curiosity (Clain 1968, Ocuda 1976)
- Investigation of portal hypertension (Moreno 1963)
- Hepatic Lymphorea (Matsumoto 2000)
- Lymph nodes metastasis (Teramoto 2002)

Liver Lymphorea

Penn/CHOP Experience
- Liver Lymphorea
- Ascites
- Protein Loosing Enteropathy (PLE)

Hepatic Lymphorea

56-year-old male
History of hepatitis
Whipple procedure
Postoperatively large volume ascites
Denver Shunt failed
Outcome

- One paracentesis day after the procedure-cured from ascites
- US showed periportal thickening

Ascites in Right Side CHF

- 60 YO
- Tricuspid valve insufficiency (repaired)
- Developed severe ascites few months after surgery
- Not clear chylous
Outcome

Significant improvement of the ascites
- Prior to procedure twice a week
- After 14 days one parenthesis (3 liters)

Protein Loosing Enteropathy
Severe loss of serum proteins into the intestine

PLE Pathophysiology Concept

Physiology:
- Liver generates albumin and delivers it into blood stream through lymphatic system
- Liver lymph high concentration of proteins
- The lymphatic flow in liver increases significantly in patients with CHF

Hypothesis:
- The loss of the albumin in PLE happens from the liver lymph leaking into the intestine

PLE Treatment Concept

Perform liver lymphangiogram
If leak attempt to embolize

Liver Lymphangiogram PLE

Intraprocedure Endoscopy

Injection of the methylene blue into liver lymphatic ducts
Patient 1

Outcome

Patient 3

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Thoracic Duct Externalization

- Drainage of the TD was attempted in the past for:
  - T cell depletion therapy-kidney rejection
  - Treatment of the CHF and ascites in liver Cirrhosis
  - Diagnosis of the infections diseases

- Problem
  - Unpredictable anatomy
  - No Imaging
  - Surgical techniques are too invasive


Surgical Drainage

Thoracic Duct Externalization

- MR Imaging—can plan the procedure
- Minimally invasive technique
  - Quick procedure
  - Minimal Mortality and Morbidity
  - Physiological Monitoring
    - Flows and pressures


Congenital Lymphodysplasia

Diaphragm
TD Injection

TD Externalization

TD Drainage

Before After

Congenital Lymphatic Dysplasia

Before After

Congenital Lymphatic Dysplasia
Where we are today...

1. Treatment of Chylothorax
   • 100% success rate in treatment of traumatic chylothorax
   • 95-100% success rate in treatment of non traumatic chylothorax
2. Discovered etiology and developed treatment for Plastic Bronchitis
   • 94% success
3. Discovered etiology and developed treatment for Neonatal Chylothorax
4. Discovered etiology and developed treatment for Protein Losing Enteropathy
5. Discovered etiology and conceptualized treatment Pulmonary Lymphangiomatosis
6. Successful treatment of Chylous Ascites

Future...

MRL and Lymphatic Embolization
Liver Lymphatic Embolization
Thoracic Duct Externalization

Chronic Bronchitis
Intestinal Lung Disease
Bronchopulmonary Dysplasia
Cardiac Ascites
Liver Cirrhosis Ascites
Congenital Lymphedema
HIV
Immunotherapy (car T cell)
T cell depletion therapy

Development of the new lymphatic imaging agents
Development of the new treatment of the CHF
Development of Pulmonary Perfusion Syndrome
Development of the Lymphatic Pump

Team

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Conclusion

The lymphatic imaging will change the way we practice the medicine

Next Frontiers
• CHF
• Ascites in liver cirrhosis and cardiac
• HIV
• Cancer Therapy
• Lympedema

More discoveries are ahead of us...
Non Traumatic Chylothorax

No recent recorded trauma
• Yes extended history

Non-Traumatic Chylothorax-
Indications

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<td>Total</td>
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Non-Traumatic Chylothorax-
Results

Clinical success “intent to treat” 18/35 (53%)
Group post successful embolization
• 16/24 (67%)
Clinical success lymphangiogram only
• 2

Non-Traumatic Chylothorax-
Results-Imaging

Two main groups
1. Occlusion/Leak of/from the TD (88%)
2. Normal TD and CC (16%)

Occlusion of TD

Occlusion of TD-Chylopericardium

TD Occlusion

Lymphoma

Leak From Upper Part of TD

Leaking Branch

Embolization of the TD

Non-Traumatic Chylothorax-
Normal TD

Causes of chylothorax

1. Chylous ascites
2. Lymphatic masses (lymphangioma)
Chylous Ascites
In case of simultaneous chylous ascites and chylothorax
• Source is in the abdomen
• Chylothorax is secondary
Negative chest pressure

Holes in the Diaphragm

Lymphatic Malformations

Non-Traumatic Chylothorax
Diagnostic Work-Up
1. Exclude chylous ascites
2. MR lymphangiogram (Contrast and Non-contrast)
   • Exclude lymphatic malformations
   • Identify the source of the leak
3. Conventional lymphangiogram
   • Exclude patent thoracic duct

Non-Traumatic Chylothorax
Algorithm