IR Procedure

There's an ~~App~~ For That

IR Services for the Inpatient and Ambulatory Practice

Casey Cable, M.D.

9-17-2022

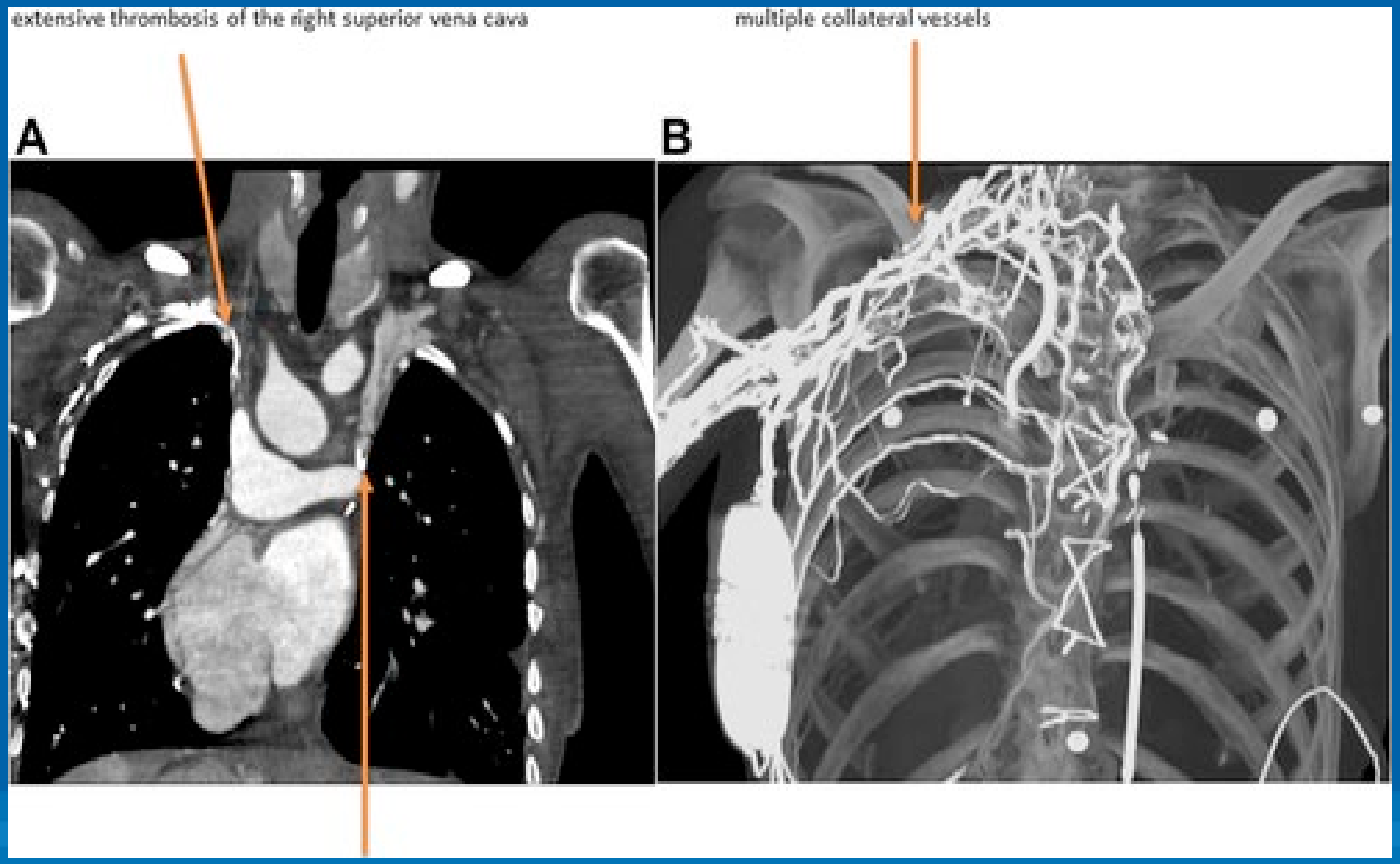
Inland Imaging

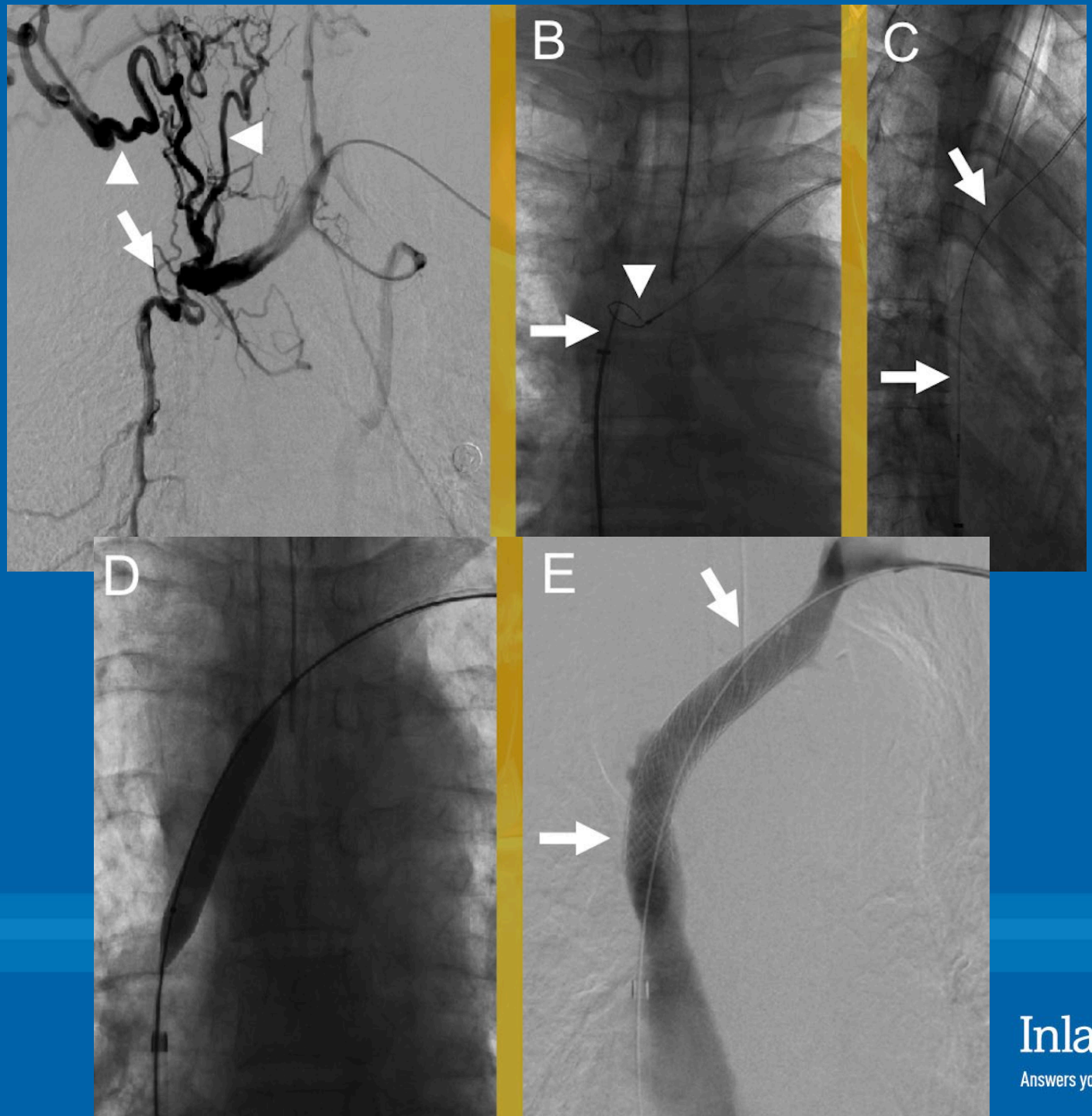
Answers you can trust and care you can count on.

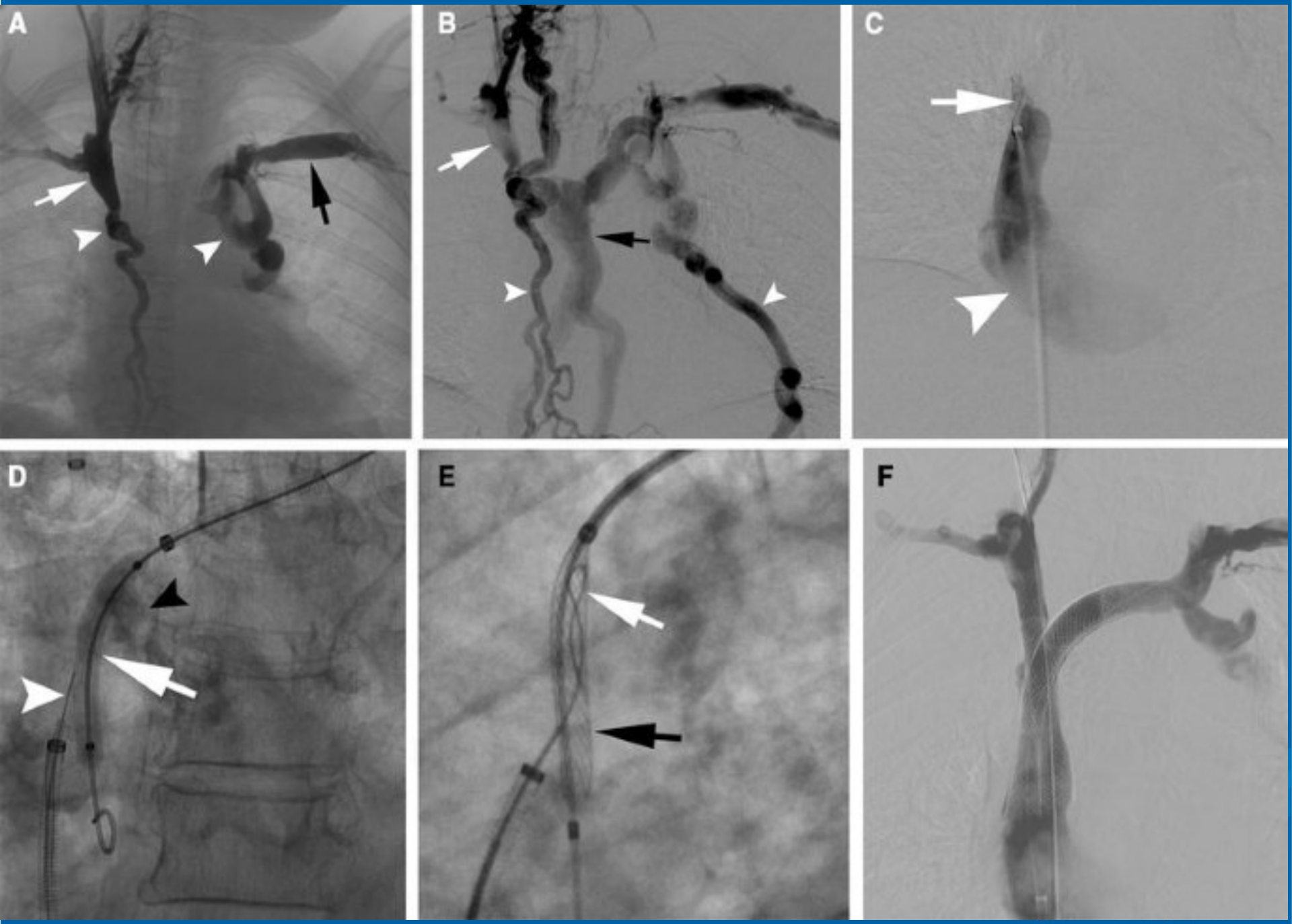
Lines, Tubes, and Biopsies OH MY!

- PICC lines, Tunneled Lines, Ports
- Gastrostomy tubes, Suprapubic tubes
- US, CT, Fluro guided biopsies
- Para's/Thora's, and Tunneled drains
- Dialysis interventions

Friday 4:30pm consult: tunneled femoral dialysis catheter not functioning……






A
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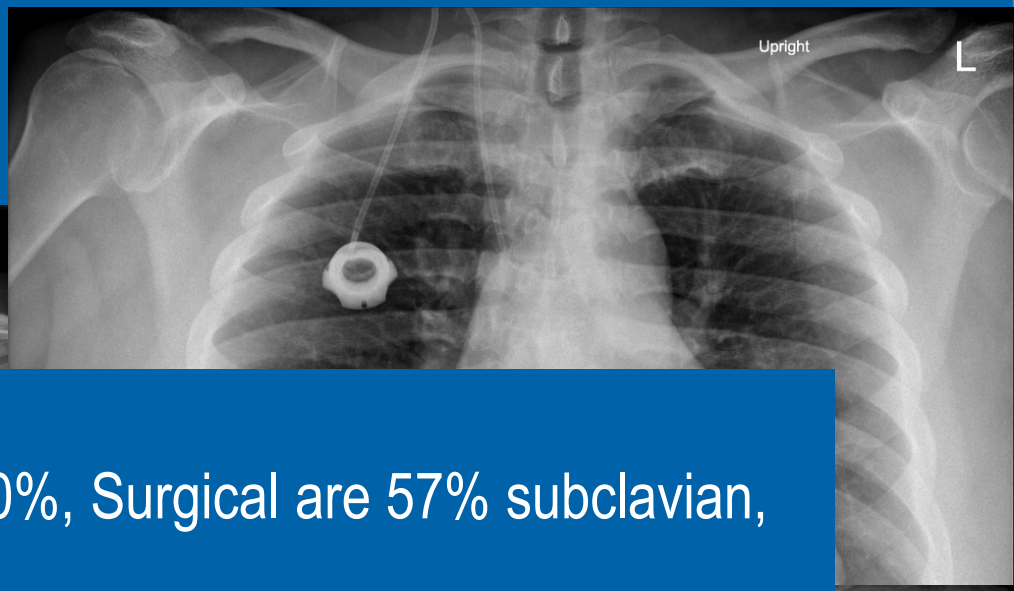
Central Venous Ports

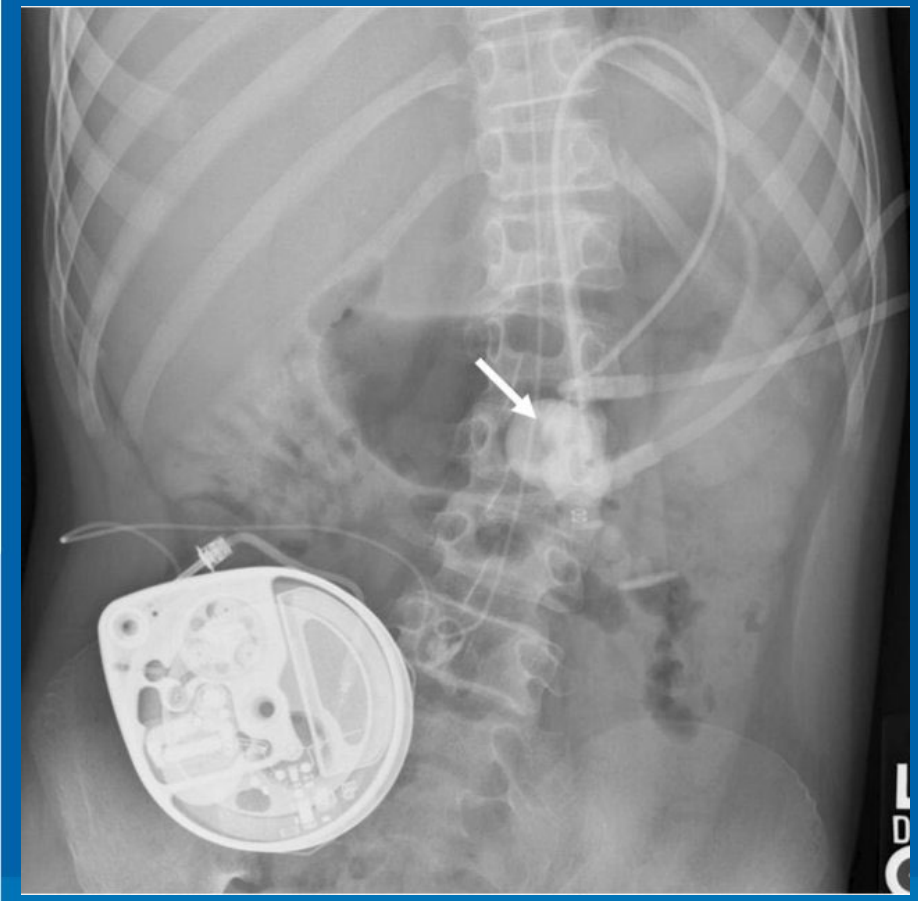


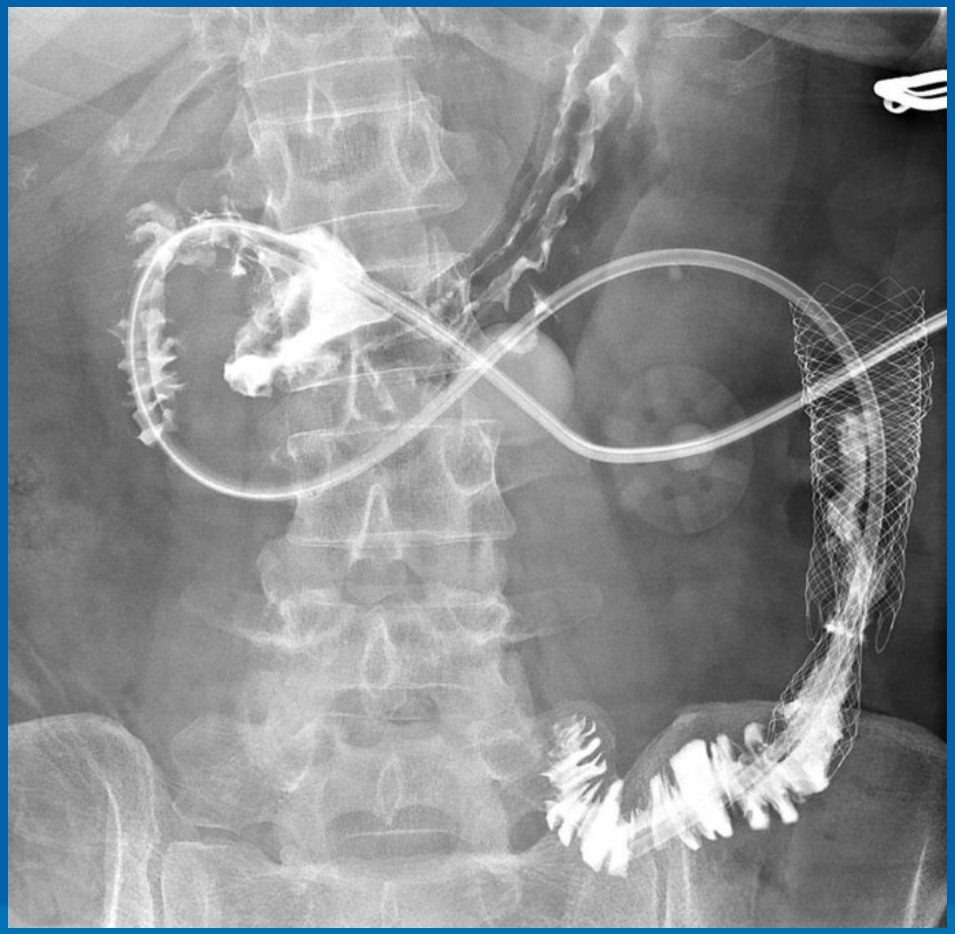
IR Placed Ports

- IR placed ports are IJ 100%, Surgical are 57% subclavian, 43% IJ
- IR ports had lower complications (1.5% vs 5.6%)
- IR ports had less malposition (0 vs 2.1%)
- IR ports had less fibrin sheath formation (0.6 vs 3.8%)
- IR ports cost less ($8,700 vs $11,252)

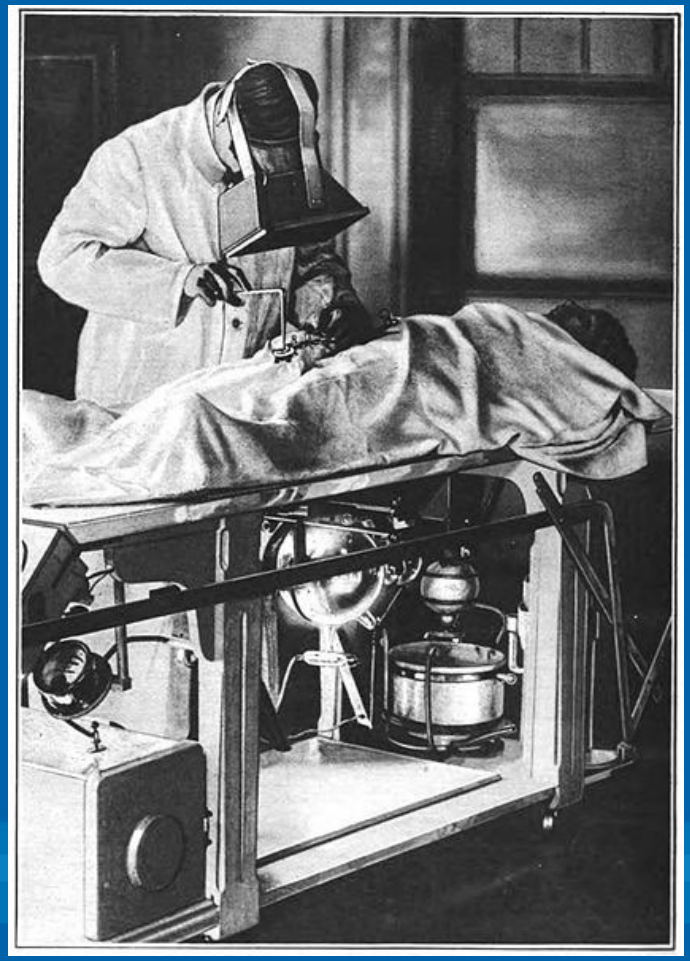
Comparison of Complications and Costs related to IR vs. surgically placed central venous access ports in the hospital setting: a retrospective chart review. J. Schiavi, et all, JVIR 2014

Gastrostomy tubes





Lions, Tigers, Bears….and Zebras?



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Embolization Procedures

- Trauma
- GI Bleeds
- Epistaxis
- Carotid body tumors
- Pseudoaneurysm
- Pulmonary AVM
- Bronchial artery
- Portal HTN
- Pre-operative
- AML
- Etc….

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Angiomyolipomas

- Account for 3% of all renal masses
- Sporadic 80%, Tuberous sclerosis 20%
- Benign, but have tendency to rupture and bleed
- Early data: 82-94% of lesions >4cm were symptomatic. 50% of those bled
- Lipid poor AML's are more likely to bleed (84 vs 50%)

AML Treatment

- Prior to 1980's, 90% treated w/total nephrectomy (couldn't exclude RCC)
- Now often followed w/MRI
- Indications to treat:
  - >4 cm
  - Child bearing age female
  - Lipid Poor AML (<50% fat)
  - Intralesional aneurysms
  - Patients on anticoagulation

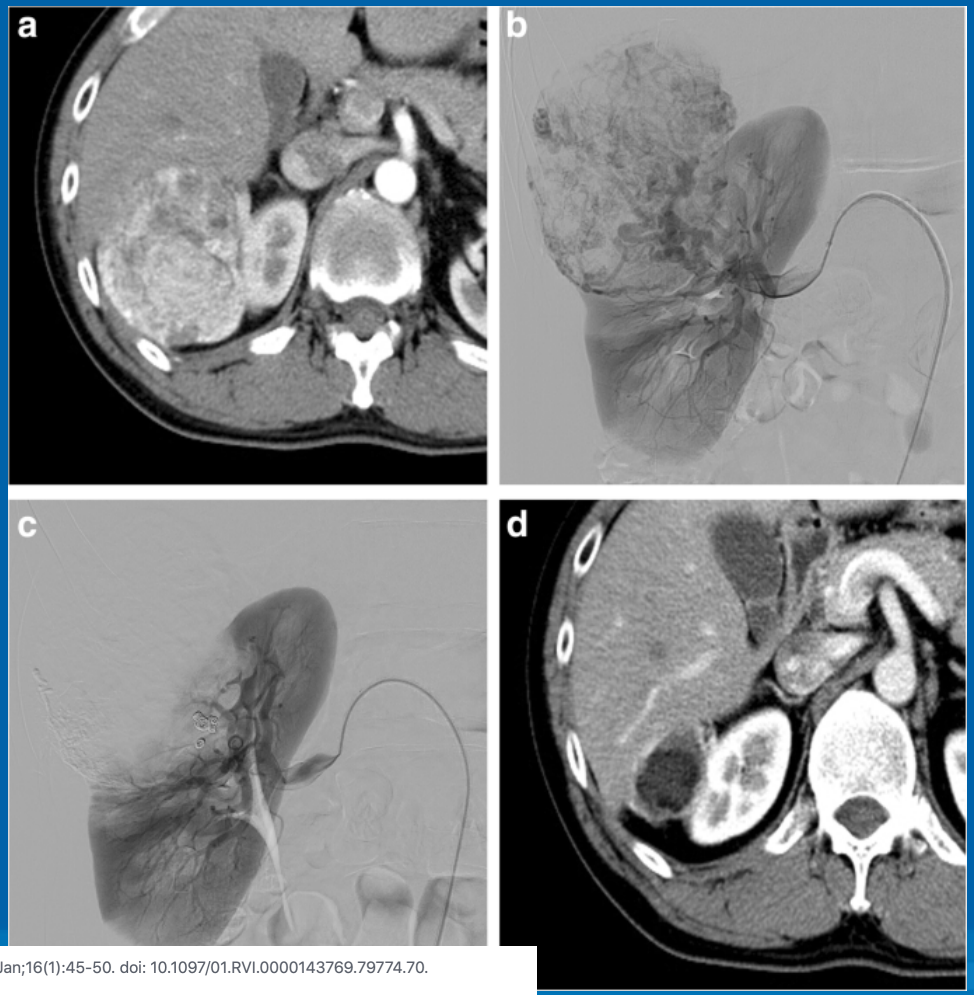
Original Article | Open Access | Published: 21 November 2020

Efficacy of prophylactic selective arterial embolization for renal angiomyolipomas: identifying predictors of 50% volume reduction

Hidenari Hongyo, Hiroki Higashihara, Keigo Osuga, Eiji Kashiwagi, Shinya Kosai, Keisuke Nagai, Kaishu Tanaka, Yusuke Ono, Takeshi Ujike, Motohide Uemura, Ryoichi Imamura, Norio Nonomura & Noriyuki Tomiyama

CVIR Endovascular **3**, Article number: 84 (2020) | Cite this article

- Technical success rate: 100%
- Complications: no severe (no significant decrease in renal function)
- Mean tumor volume reduction: 66% for all AML's (73% for TSC AMLs)
- Regrowth rate of 20% at 3 years (almost exclusively in TSC)



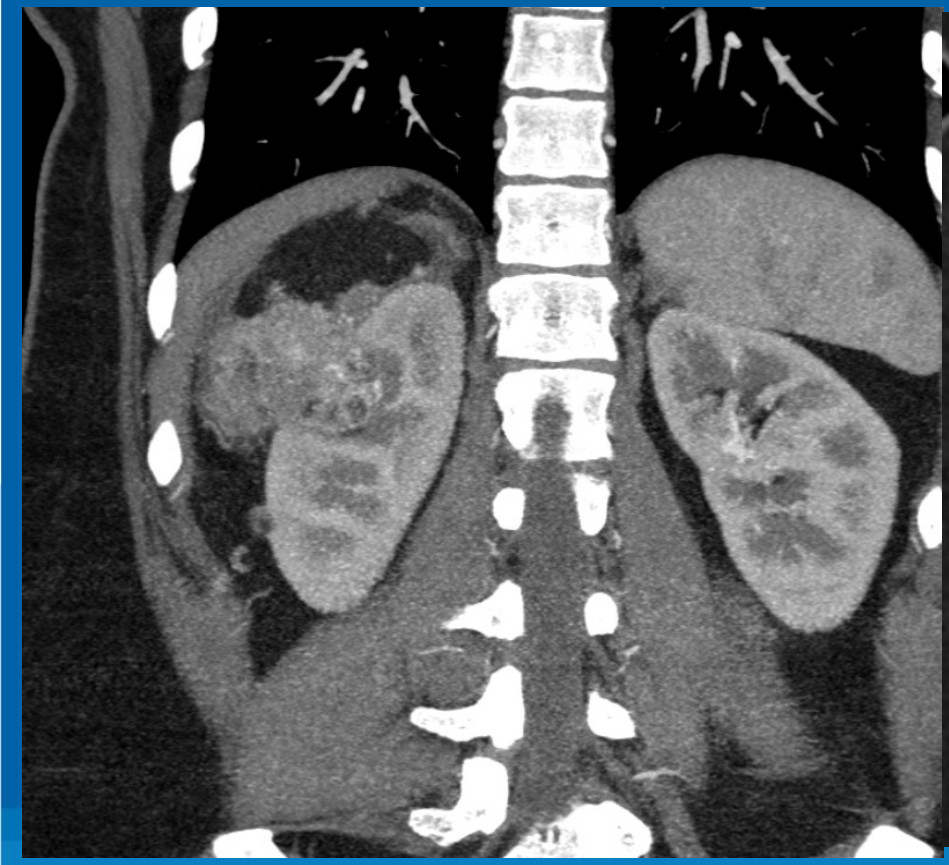
Journal of vascular and interventional radiology : JVIR
2005 Jan;16(1):45-50. doi: 10.1097/01.RVI.0000143769.79774.70.

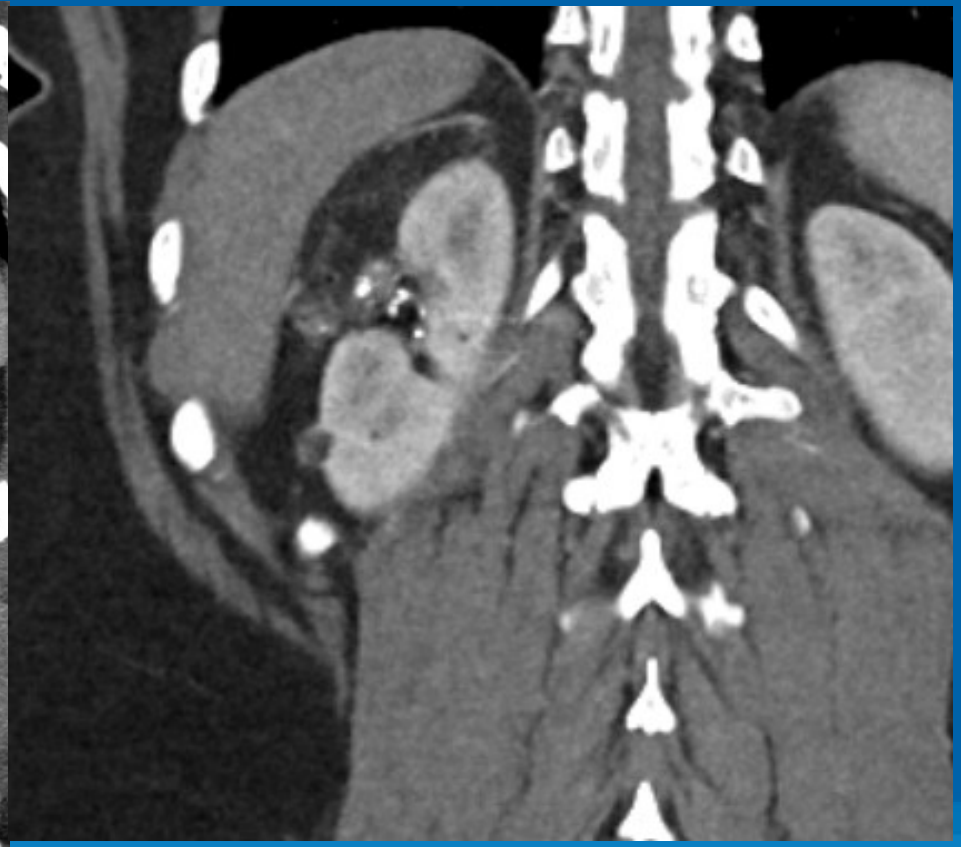
Renal angiomyolipoma: long-term results after arterial embolization

Nishita Kothary [1], Michael C Soulen, Timothy W I Clark, A J Wein, Richard D Shlansky-Goldberg, Peter B Crino, S William Stavropoulos

Affiliations + expand

PMID: 15640409 DOI: 10.1097/01.RVI.0000143769.79774.70





Interventional Oncology

- TACE
- Y90
- Cryoablation
  - Renal, liver, bone mets, nerve ablation
- Microwave ablation
  - Liver, lung
- Radiofrequency ablation
  - Liver, RCC, lung, spinal mets
- Hepatic deprivation
  - Induces remnant liver hypertrophy
- Immunotherapy
  - Melanoma
- Pain Interventions
  - RFA
  - Vertebral Augmentation
  - Nerve blocks

NCCN Guidelines

- All patients with HCC should be evaluated for potential curative therapies (resection, transplant, and for small lesions, ablative strategies).
- Locoregional therapy should be considered in patients who are not candidates for surgical curative treatments, or as a part of a strategy to bridge patients for other curative therapies.

National Comprehensive Cancer Network®

NCCN Guidelines Version 4.2021
Hepatocellular Carcinoma

NCCN Guidelines Index
Table of Contents
Discussion

PRINCIPLES OF LOCOREGIONAL THERAPY

I. General Principles

- All patients with HCC should be evaluated for potential curative therapies (resection, transplantation, and for small lesions, ablative strategies). Locoregional therapy should be considered in patients who are not candidates for surgical curative treatments, or as a part of a strategy to bridge patients for other curative therapies. These are broadly categorized into ablation, arterially directed therapies, and radiotherapy.

II. Treatment Information

A. Ablation (radiofrequency, cryoablation, percutaneous alcohol injection, microwave):

- All tumors should be amenable to ablation such that the tumor and, in the case of thermal ablation, a margin of normal tissue is treated. A margin is not expected following percutaneous ethanol injection.
- Tumors should be in a location accessible for percutaneous/laparoscopic/open approaches for ablation.
- Caution should be exercised when ablating lesions near major vessels, major bile ducts, diaphragm, and other intra-abdominal organs.
- Ablation alone may be curative in treating tumors ≤3 cm. In well-selected patients with small properly located tumors, ablation should be considered as definitive treatment in the context of a multidisciplinary review. Lesions 3 to 5 cm may be treated to prolong survival using arterially directed therapies, or with combination of an arterially directed therapy and ablation as long as tumor location is accessible for ablation.[1-3]
- Unresectable/inoperable lesions >5 cm should be considered for treatment using arterially directed therapy, systemic therapy, or EBRT.[4-6]
- Sorafenib should not be used as adjuvant therapy post-ablation.[7]

B. Arterially Directed Therapies:

- All tumors irrespective of location may be amenable to arterially directed therapies provided that the arterial blood supply to the tumor may be isolated without excessive non-target treatment.
- Arterially directed therapies include bland transarterial embolization (TAE),[4,5,8,9] chemoembolization (transarterial chemoembolization [TACE][10] and TACE with drug-eluting beads [DEB-TACE][6,11]), and radioembolization (RE) with yttrium-90 (Y-90) microspheres.[12,13]
- All arterially directed therapies are relatively contraindicated in patients with bilirubin >3 mg/dL unless segmental treatment can be performed.[14] RE with Y-90 microspheres has an increased risk of radiation-induced liver disease in patients with bilirubin >2 mg/dL.[13]
  - With RE, delivery of ≥205 Gy to the tumor may be associated with increased overall survival.[15]
- Arterially directed therapies in highly selected patients have been shown to be safe in the presence of limited tumor invasion of the portal vein.
  - Randomized controlled trials have shown that Y-90 is not superior to sorafenib for treating advanced HCC. RE may be appropriate in some patients with advanced HCC,[19-20] specifically patients with segmental or lobar portal vein, rather than main portal vein thrombosis.[22]
- Sorafenib may be appropriate following arterially directed therapies in patients with adequate liver function once bilirubin returns to baseline if there is evidence of residual/recurrent tumor not amenable to additional local therapies. The safety and efficacy of the use of sorafenib concomitantly with arterially directed therapies has not been associated with significant benefit in three randomized trials; other randomized phase III trials are ongoing to investigate other systemic therapies including immunotherapy in combination with arterial therapies.[15-17,22]

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Potentially Resectable HCC

Ablation

- RFA, MWA, Cryo, percutaneous EtOH
- **"In-well selected patients with small, properly located tumors, ablation should be considered as definitive treatment in the context of multidisciplinary review."**
- ≤3 cm, location amenable to ablation
- 3-5 cm (**combination** of ablation and arterially directed therapy)
- >5cm (**ablation NOT recommended**)
- Sorafenib should NOT be used as adjuvant post-ablation

Downstaging

- **For tumor burden beyond accepted transplant criteria w/ the goal of future transplant**
- Meta-analysis[1]: **Downstaging improved 1 and 5 year OS post OLT vs. OLT alone**
- Systematic review[2]: 48% success rate to transplant eligibility in 950 pts
- Phase IIb/III[3]: downstaging with locoregional rx, surgery or systemic therapy prior to transplant vs. observation
  - 5-year OS: 78% vs. 31%

What about EBRT or SBRT?

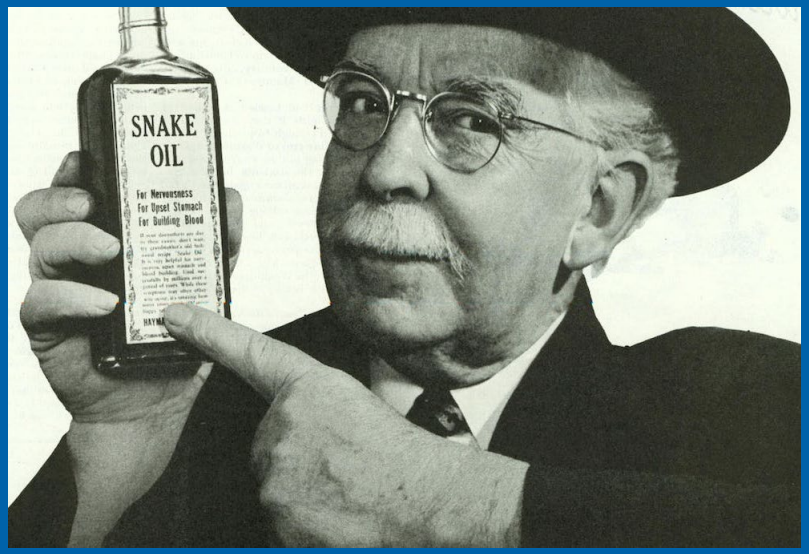
- **"Should be considered as an alternative to ablation and/or embolization techniques when these therapies have failed or are contraindicated"**
- Palliative setting for symptom control and prevention of complications from metastatic disease (bone and brain)
- Encourages prospective trials to determine role of SBRT in pts with unresectable locally advanced disease

RFA/Kyphoplasty

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 AUGUST 6, 2009 VOL. 361 NO. 6

A Randomized Trial of Vertebroplasty for Painful Osteoporotic Vertebral Fractures



CONCLUSIONS

We found no beneficial effect of vertebroplasty as compared with a sham procedure in patients with painful osteoporotic vertebral fractures, at 1 week or at 1, 3, or 6 months after treatment. (Australian New Zealand Clinical Trials Registry number, ACTRN012605000079640.)

Efficacy and safety of balloon kyphoplasty compared with non-surgical care for vertebral compression fracture (FREE): a randomised controlled trial

Douglas Wardlaw, Steven R Cummings, Jan Van Meirhaeghe, Leonard Bastian, John B Tillman, Jonas Ranstam, Richard Eastell, Peter Shabe, Karen Talmadge, Steven Boonen

- RCT comparing effects of Kyphoplasty vs medical management of osteoporotic and pathologic VCF's
- Multicenter, multinational study, w/300 patients enrolled over 2 years
- Inclusion criteria based on MR findings, clinic exam

- Outcome measures: WOL, back function and mobility scores, back pain, narcotic analgesic use, and # of restricted activity days.
- Kypo was superior to non-op for all primary and secondary outcome measures at 6 and 12 months.
- No difference in adverse events

Lancet 2009; 373: 1016–24
Published Online February 25, 2009
DOI:10.1016/S0140-6736(09)60010-6

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 AUGUST 6, 2009 VOL. 361 NO. 6

A Randomized Trial of Vertebroplasty for Painful Osteoporotic Vertebral Fractures

Rachelle Buchbinder, Ph.D., Richard H. Osborne, Ph.D., Peter R. Ebeling, M.D., John D. Wark, Ph.D., Peter Mitchell, M.Med., Chris Wriedt, M.B., B.S., Stephen Graves, D. Phil., Margaret P. Staples, Ph.D., and Bridie Murphy, B.Sc.

- RCT: 78 patients
- 38 vertebroplasty : 40 sham
- All enrolled had edema on MRI
- No demographic or fracture differences
- No pain score, disability or QoL differences at
  - T=0
  - 1 week (except favoring placebo)
  - 1, 3, and 6 months

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

A Randomized Trial of Vertebroplasty for Osteoporotic Spinal Fractures

David F. Kallmes, M.D., Bryan A. Comstock, M.S., Patrick J. Heagerty, Ph.D., Judith A. Turner, Ph.D., David J. Wilson, F.R.C.R., Terry H. Diamond, F.R.A.C.P., Richard Edwards, F.R.C.R., Leigh A. Gray, M.S., Lydia Stout, B.S., Sara Owen, M.Sc., William Hollingworth, Ph.D., Basavaraj Ghdoke, M.D., Deborah J. Annesley-Williams, F.R.C.R., Stuart H. Ralston, F.R.C.P., and Jeffrey G. Jarvik, M.D., M.P.H.

- RCT: 131 patients
- 68 vertebroplasty : 63 sham
- No demographic or fracture differences
- No pain score, disability or QoL differences at
  - T=0 and 1 month
- Higher crossover rates for sham to vertebroplasty

A closer look….

- Difficulty enrolling patients: 78 and 131 participants over 4 years
- Inclusion criteria did not use concordant PE findings, only relied on imaging
- Included both acute and chronic fractures
- Considerable number of patients were on chronic opioids, diluting treatment effect

- ”Multicenter” - 68% of procedures performed at single institution by 1 radiologist.
- Only unilateral approaches w/small cement volume

Vertebroplasty versus conservative treatment in acute osteoporotic vertebral compression fractures (Vertos II): an open-label randomised trial

Sept 2010

Caroline A H Klazen, Paul N M Lohle, Jolanda de Vries, Frits H Jansen, Alexander V Tielbeek, Marion C Blonk, Alexander Venmans, Willem Jan J van Rooij, Marinus C Schoemaker, Job R Juttmann, Tjoen H Lo, Harald J J Verhaar, Yolanda van der Graaf, Kaspar J van Everdingen, Alex F Muller, Otto E H Elgersma, Dirk R Halkema, Hendrik Fransen, Xavier Janssens, Erik Buskens, Willem P Th M Mali

- Vertebroplasty vs Conservative
  - Vertebroplasty: N=93
  - Conservative: N=95
  - All had edema on MRI
- Results
  - Mean treatment time at 5.9 weeks from injury
  - Sig improvement in VAS, QUALEFFO and RMD scores at 1 day, 1 month
  - Vertebroplasty had greater and quicker pain improvement (29.7 days vs 115.6 days)

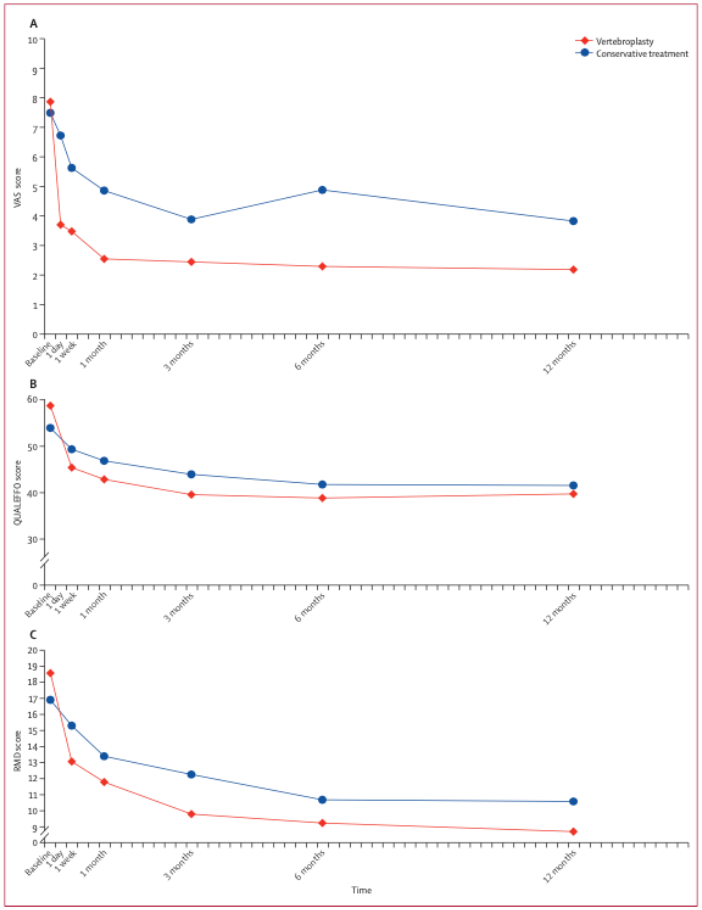
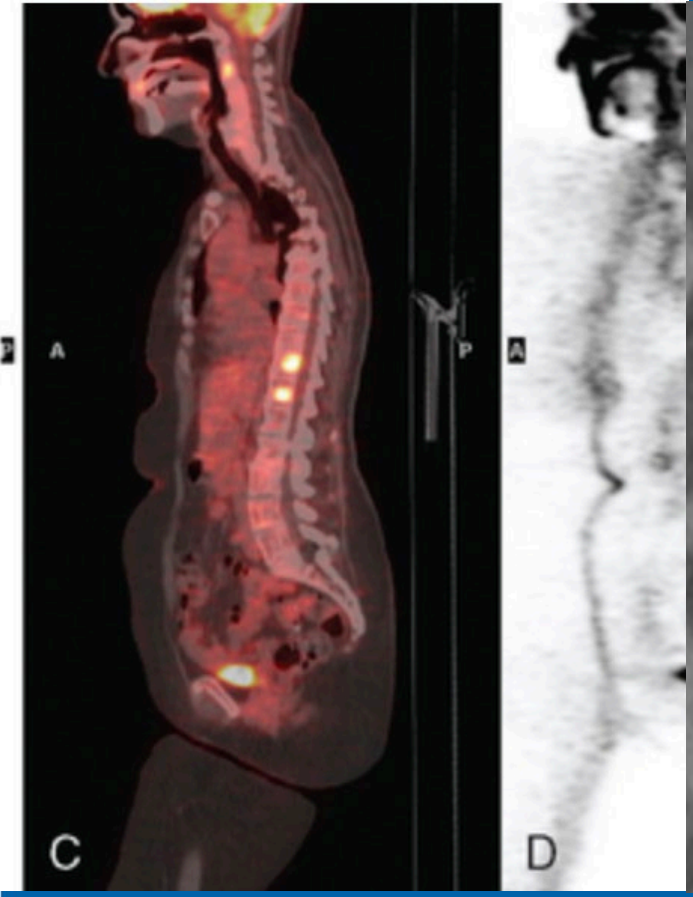
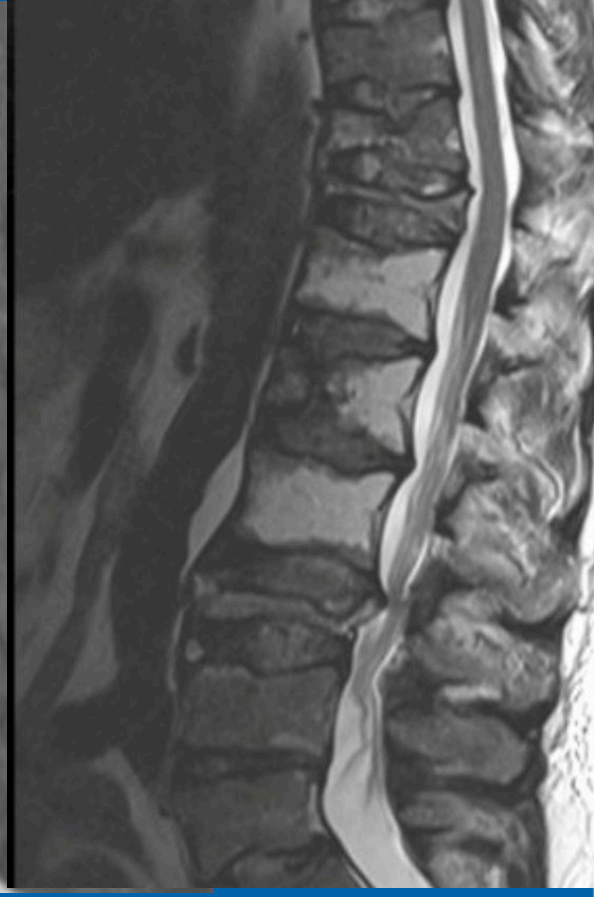


Figure 2: Analysis of variance models for VAS (A), QUALEFFO (B), and RMD scores (C) in vertebroplasty and conservative treatment groups during follow-up
VAS=visual analogue scale. QUALEFFO=Quality of Life Questionnaire of the European Foundation for Osteoporosis. RMD=Roland Morris Disability.





Vertebral Body Augmentation for Malignancy

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CAFE Trial 2011

Procedure in Oncology Patients versus Non-operative

Balloon kyphoplasty versus non-surgical fracture management for treatment of painful vertebral body compression fractures in patients with cancer: a multicentre, randomised controlled trial

*James Berenson, Robert Pflugmacher, Peter Jarzem, Jeffrey Zonder, Kenneth Schechtman, John B Tillman, Leonard Bastian, Talat Ashraf, Frank Vrionis, for the Cancer Patient Fracture Evaluation (CAFE) Investigators**

- RCT: kyphoplasty vs conservative
- May 2005 — March 2008
- Enrolled
  - Kypho: N= 70
  - Conservative: N=64
- Completed follow up
  - Kypho: N=75
  - Conservative: N=52
- 38 patients in control group crossed over at 1 month (mean 47 days)
- ~50% had prior radiation
- Baseline characteristics similar

- **Inclusion criteria**
  - 1-3 pathologic vertebral compression fractures
  - NRS pain score ≥ 4
  - Roland-Morris disability questionnaire (RDQ) ≥ 10
- **Exclusion criteria**
  - Osteoblastic mets or Primary bone tumors
  - Concurrent phase 1 anticancer therapy study
  - Short life expectancy due to comorbidities
  - Loss of cortical integrity or posterior wall involvement
  - Epidural involvement
  - Required high-dose steroids, nerve blocks or PCA pumps to control baseline back pain not related to VCF

Lancet Oncol 2011; 12: 225–35
Published Online February 17, 2011
DOI:10.1016/S1470-2045(11)70008-0

CAFE Trial Results

- Results–significant differences at 1 month between groups in:
  - Roland Morris disability questionnaire (functional status)
  - Karnofsky performance score (performance status)
  - SF-36 PCS score (quality of life – physical)
  - SF-36 MCS score (quality of life – mental)
  - Reduced activity days
  - Bed rest days

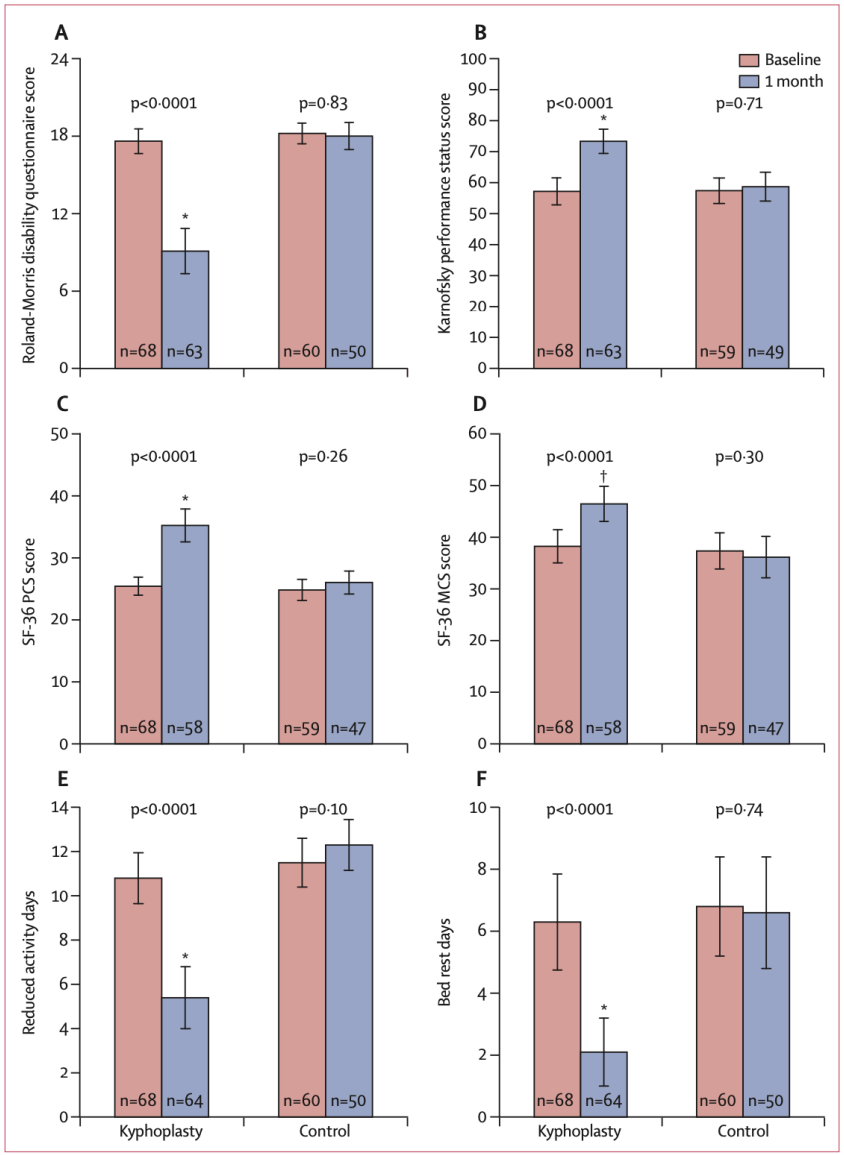


Figure 2: Disability and quality of life at baseline and after 1 month

CAFE Trial Results

At 1 month, kyphoplasty group had:

- Decreased pain scores
- Decreased analgesics

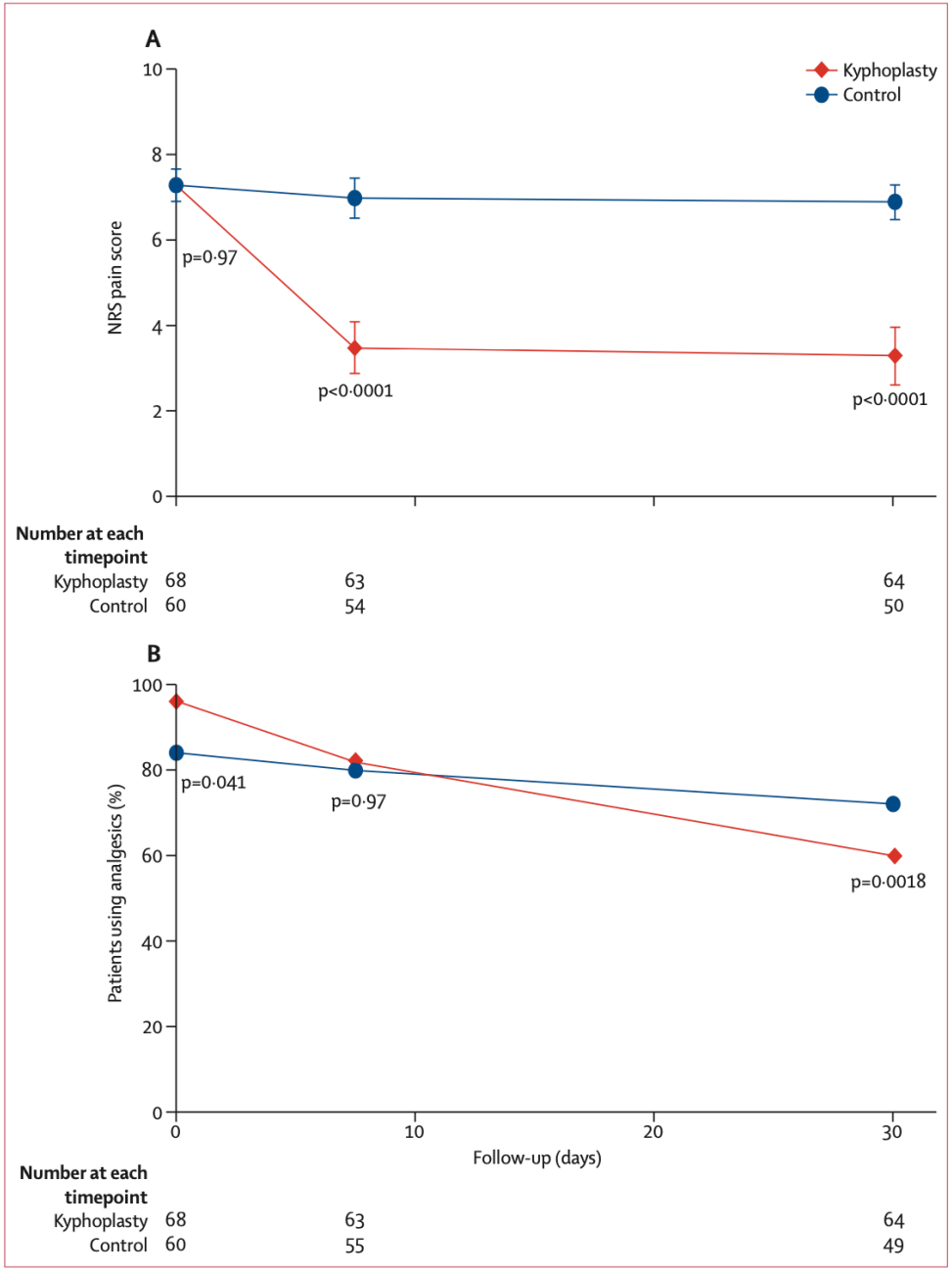


Figure 3: **Back pain and pain management during the first month**
(A) Means and 95% CIs for the back pain numerical rating score (NRS; scale 0 to 10). ANOVA p values are shown. (B) Percentage of patients using analgesics for back pain. Cochran-Mantel-Haenszel χ^2 p values are shown. For both panels, lower scores show improvement.

CAFE Trial Results

	Kyphoplasty		Control		p value at 1 month*
	Baseline (n=68)	1 month (n=65)	Baseline (n=61)	1 month (n=50)	
Walking aids	22 (32%)	16 (25%)	22 (36%)	23 (46%)	0·028
Bracing	9 (13%)	1 (2%)	10 (16%)	11 (22%)	0·001
Wheelchair	5 (7%)	1 (2%)	3 (5%)	2 (4%)	0·58
Bed rest	29 (43%)	15 (23%)	32 (52%)	23 (46%)	0·016
Physical therapy	11 (16%)	3 (5%)	8 (13%)	6 (12%)	0·18
Any medication	64 (94%)	34 (52%)	51 (84%)	41 (82%)	0·001
Radiation therapy	4 (6%)	3 (5%)	1 (2%)	4 (8%)	0·70

Patients might have received more than one treatment. *p value is for difference between groups at 1 month.

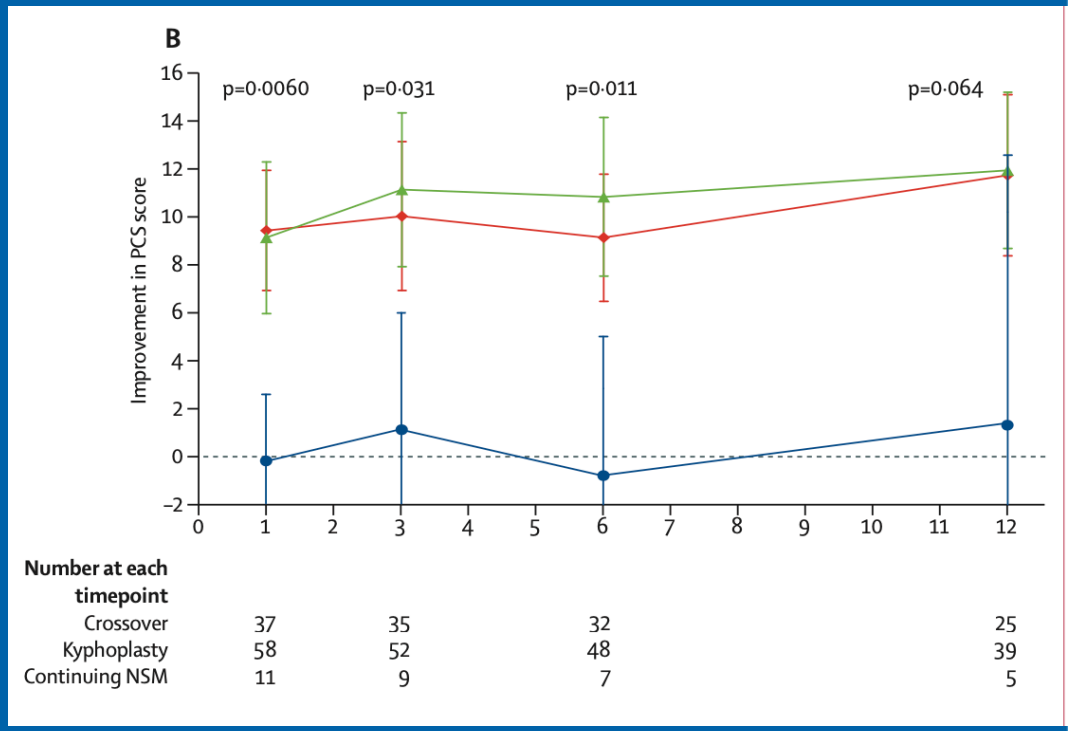
Table 2: **Non-surgical treatments for index vertebral compression fractures**

At 1 month, kyphoplasty group had decreased:

- Walking aids
- Bracing
- Bed rest
- Any medication for pain

CAFE Trial Results

- At 6 months, kyphoplasty and cross-over group had persistent significantly different:
  1. Improvement in functional status on RDQ
  2. Improvement in quality of life on SF-36, on both physical and mental components



Radiofrequency Ablation Data

- Prospective, nonrandomized, single arm, multicenter trial from 2017-2019
- Evaluate effectiveness for rapid (<3 days) and sustained pain relief in bone mets
- 106 patients enrolled @ 14 centers
- **Inclusion criteria:**
  - >18 y.o.
  - Metastatic disease in axial skeleton
- **Exclusion criteria:**
  - Pure osteoblastic tumors
  - Worst pain < 4 on a scale of 1-10
  - > 2 painful sites that would require treatment
  - Karnofsky performance scale < 40

OPuS One Trial 2020

CLINICAL STUDY

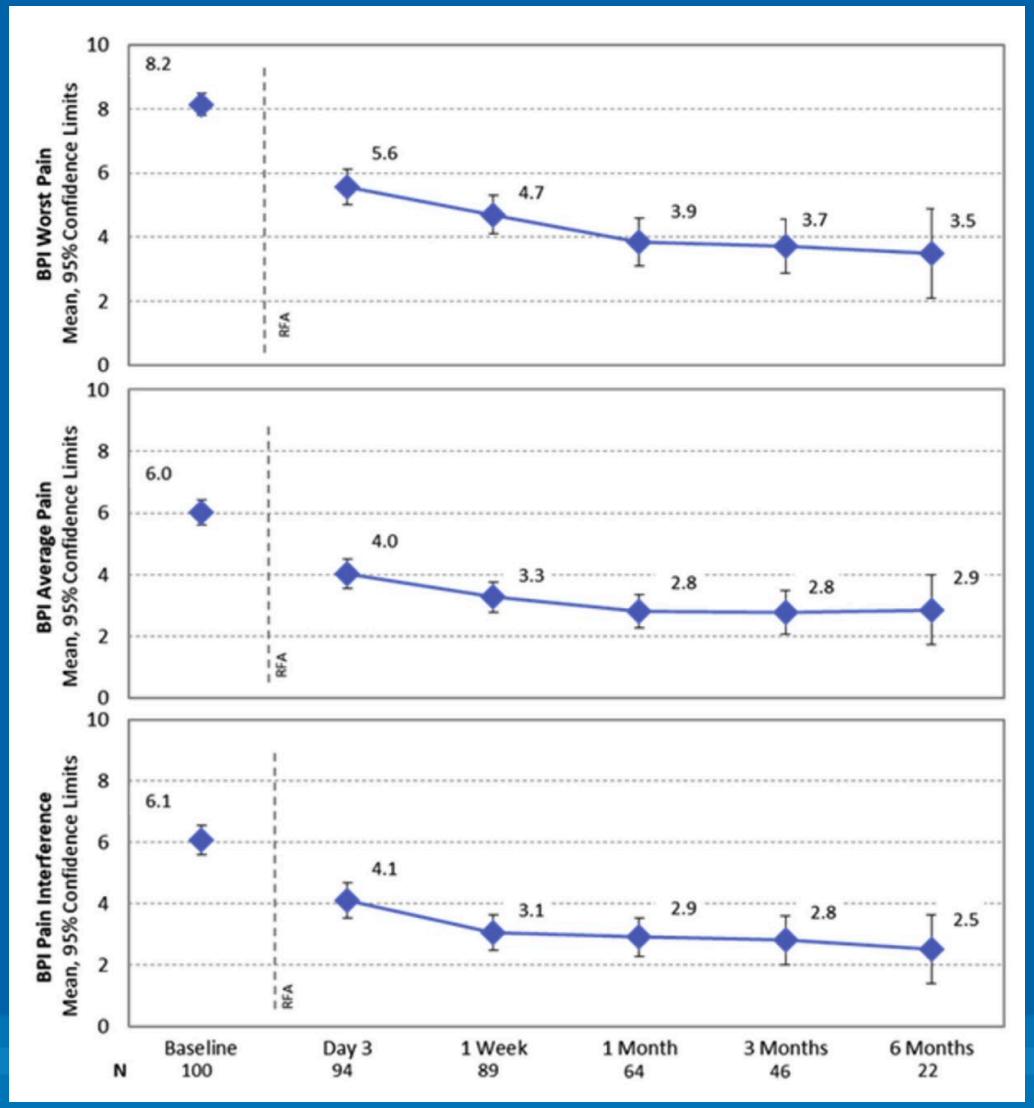
Check for updates

Radiofrequency Ablation for the Palliative Treatment of Bone Metastases: Outcomes from the Multicenter OsteoCool Tumor Ablation Post-Market Study (OPuS One Study) in 100 Patients

Jason Levy, MD, Thomas Hopkins, MD, MBA, Jonathan Morris, MD, Nam D. Tran, MD, PhD, Elizabeth David, MD, FRCPC, Francesco Massari, MD, PhD, Hamed Farid, MD, MBA, Alexander Vogel, MD, William G. O'Connell, MD, Peter Sunenshine, MD, Robert Dixon, MD, Afshin Gangi, MD, PhD, Nicolas von der Höh, MD, and Sandeep Bagla, MD

OPuS One Trial 2020

- Results:
  - Worst pain improved from mean of 7.8 to 3.6 at 3 months
  - For all ablations, all pain and QoL scores improved at all time points (3 d, 1 w, 1 m, 3 m, & 6 m)



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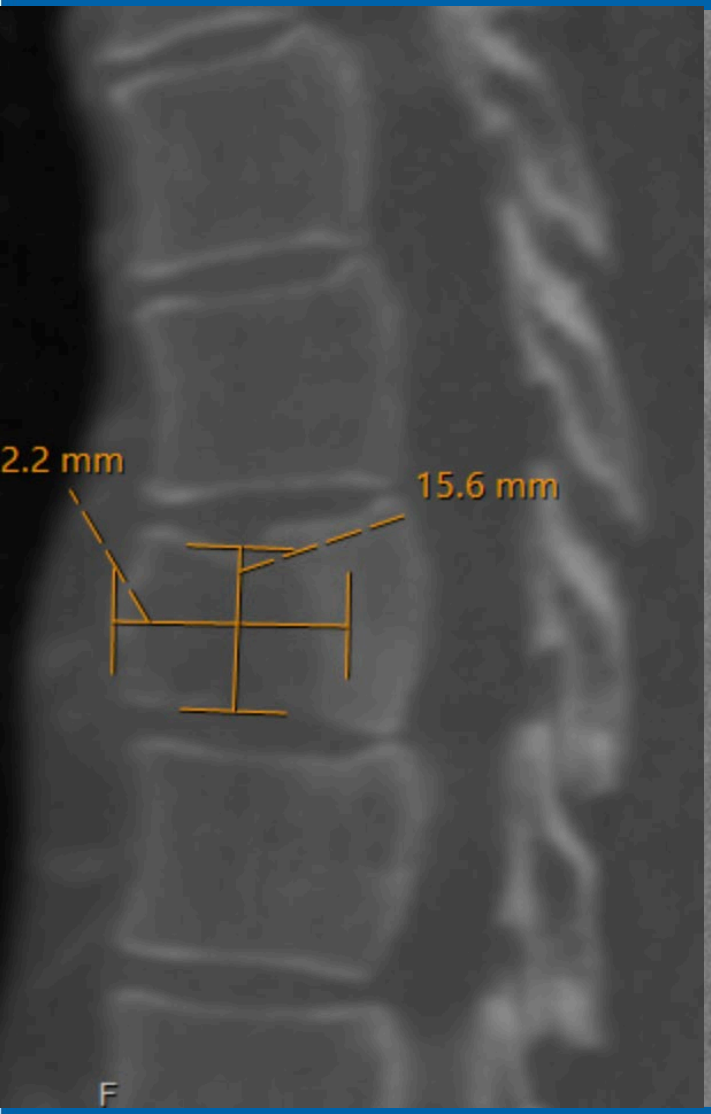
Benefits of Vertebral Augmentation + RFA

- Pain relief in 3 days (many 24hrs) compered to 3-8 wks for multi-fraction radiation
  - Treating both cancer pain (cytokines, periosteal stretch) and bone instability pain
- Addition of cementoplasty allows stabilization of bones, whereas radiation increases risk of fractures (SBRT 11-39%)
- Doesn't matter type of cancer (some cancers are not radiosensitive)
- Does not limit future therapies
  - RFA/VA followed by radiation increase response by 30% than either therapy alone
- Best intervention should be determined by multidisciplinary group of
  - Primary Team
  - Palliative
  - Radiation Oncology
  - Spinal Surgeons (Ortho spine or Neurosurgery)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15.6 mm
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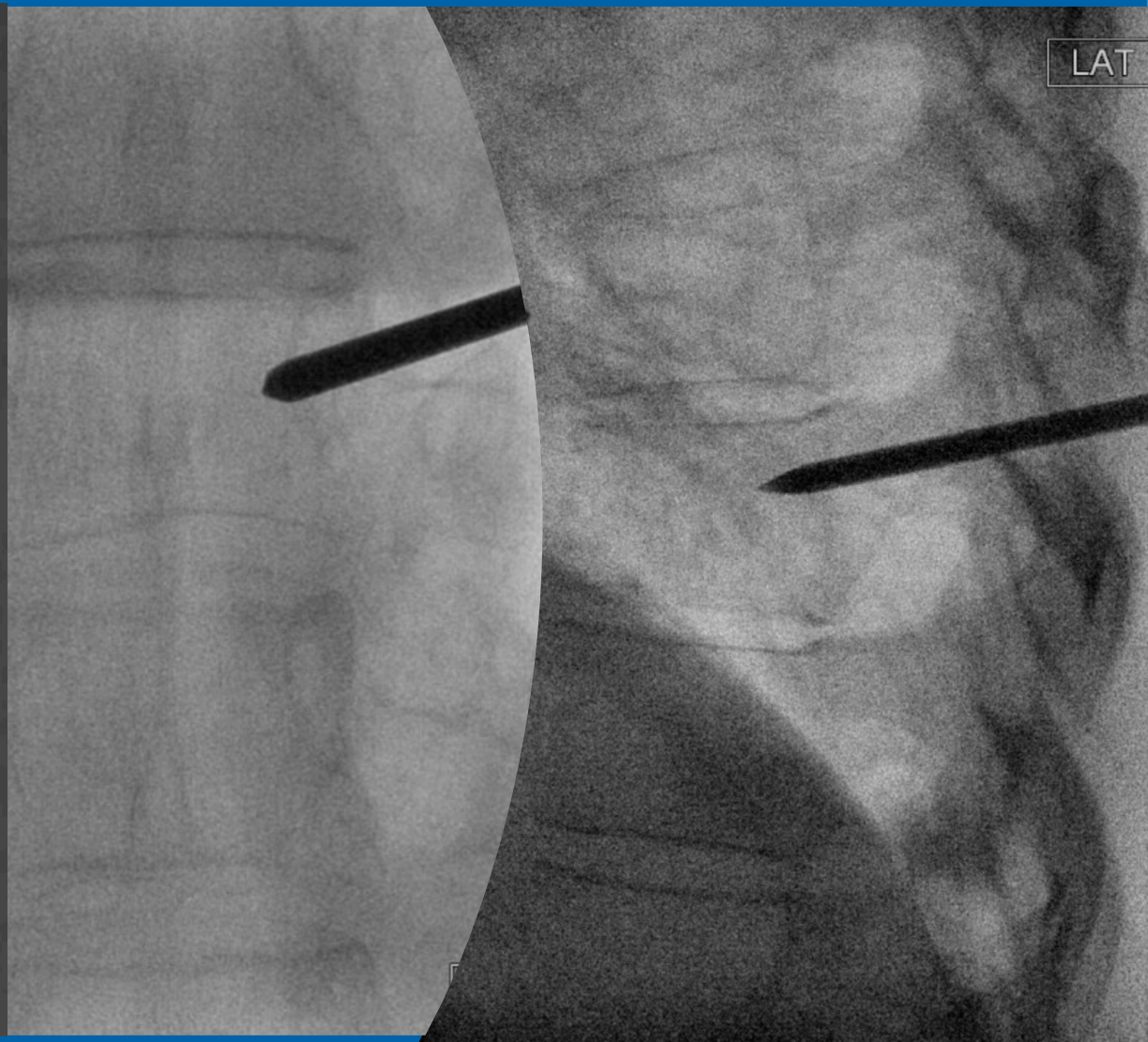
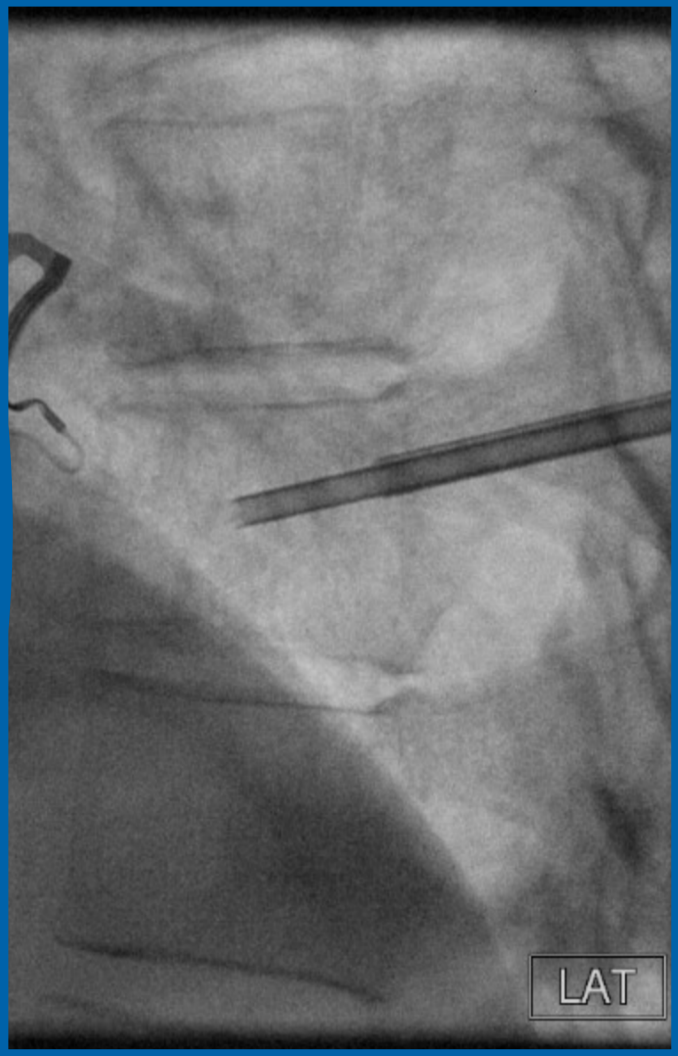

LAT



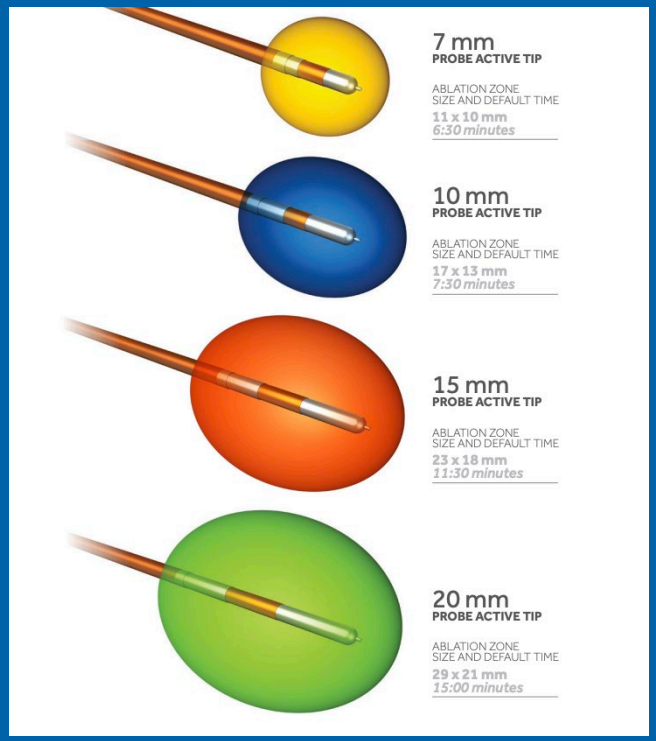
Biopsy

- 13 gauge biopsy needle (Madison)

18 gauge biopsy needle (Temno)

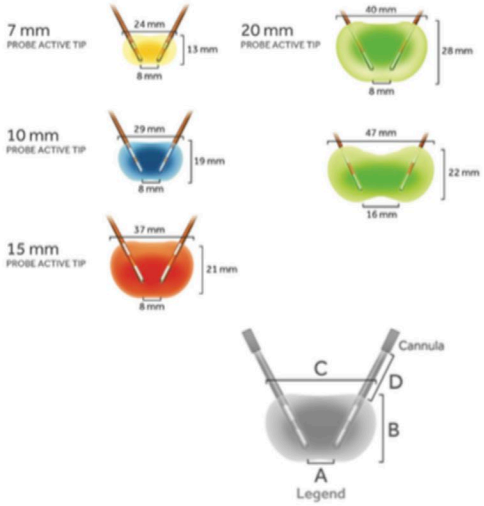
Choosing Ablation Probes

- RFA vs Cryoablation vs MWA
  - Most will be RFA, some cryo, rarely MWA
  - RFA energy doesn't go through cortical bone
  - Cryoablation – use CT, bigger lesions
- Unipedicular vs Bipedicular
  - Merit – Curved ablation probe
  - Osteocool – Linear ablation probes but can use as single (smaller) or double (larger)
- Measure lesion
- Note cortical integrity



Findings — Dual Probe Ablation Zone Measurements

Measurements were taken for a total of three ablations for each of the probe sizes.

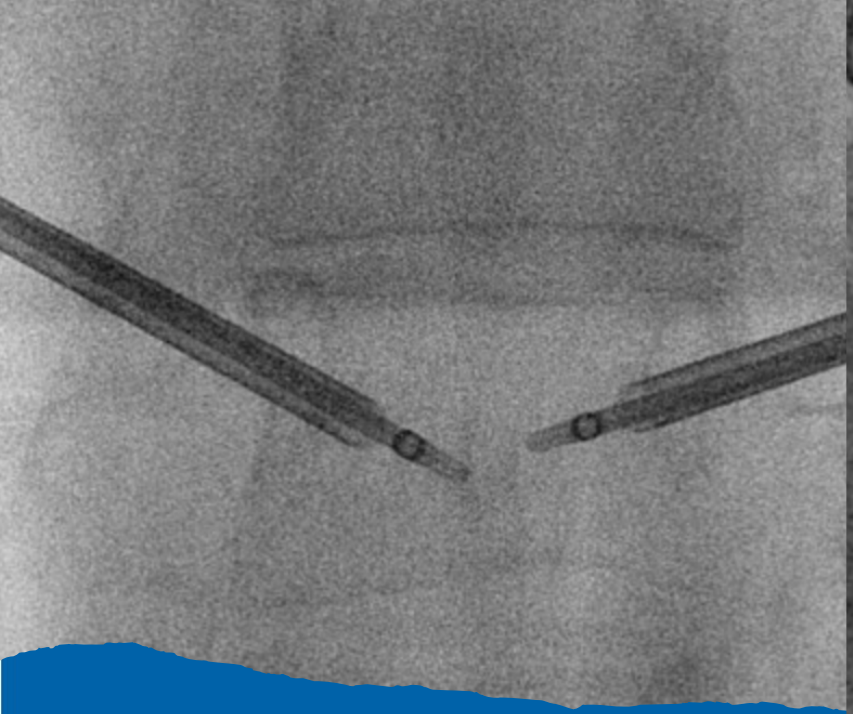


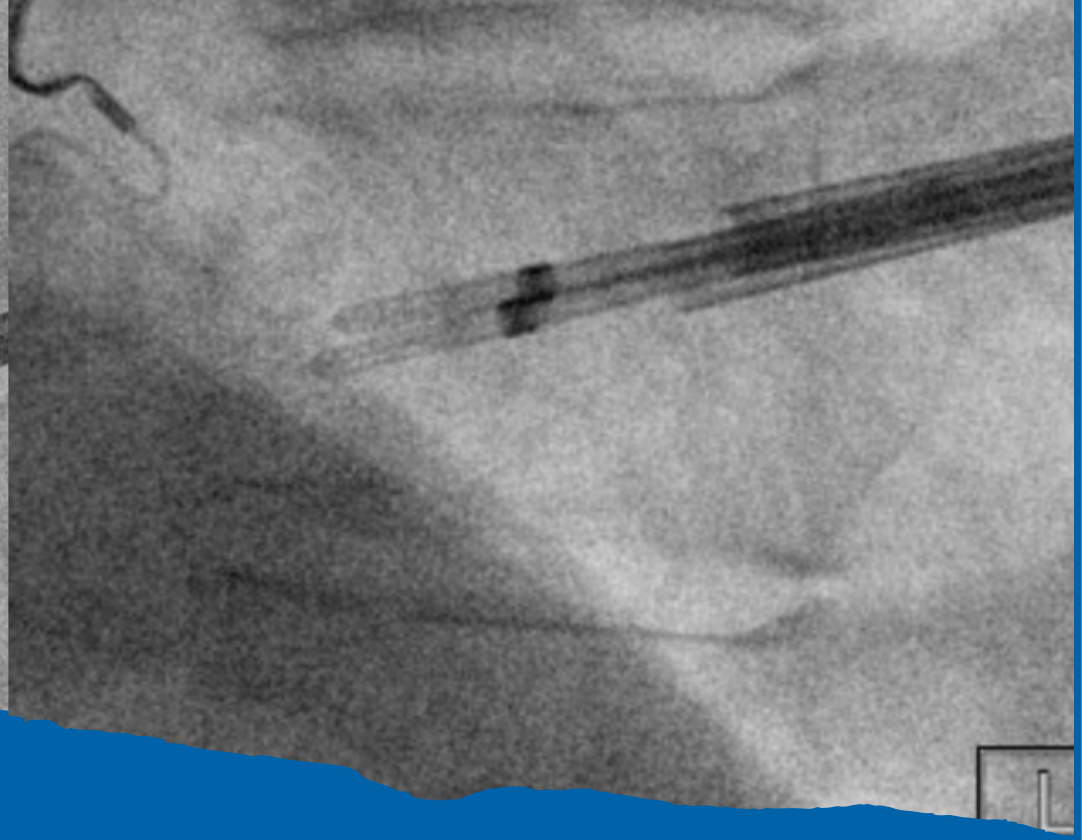
Probe size (mm)	A	B	C	D
7 mm	8	13	24	4
	12	N/A*	N/A*	N/A*
	16	N/A*	N/A*	N/A*
10 mm	8	19	29	3
	12	16	31	4
	16	N/A*	N/A*	N/A*
15 mm	8	21	37	4
	12	22	38	5
	16	N/A*	N/A*	N/A*
20 mm	8	28	40	4
	12	28	41	4
	16	22	47	5

A — Distance between probe tips
B — AP – Ablation size anterior to posterior
C — Transverse – Ablation size perpendicular to AP
D — Ablation GAP – Minimum distance between the distal end of the access cannula and the posterior ablation boundary

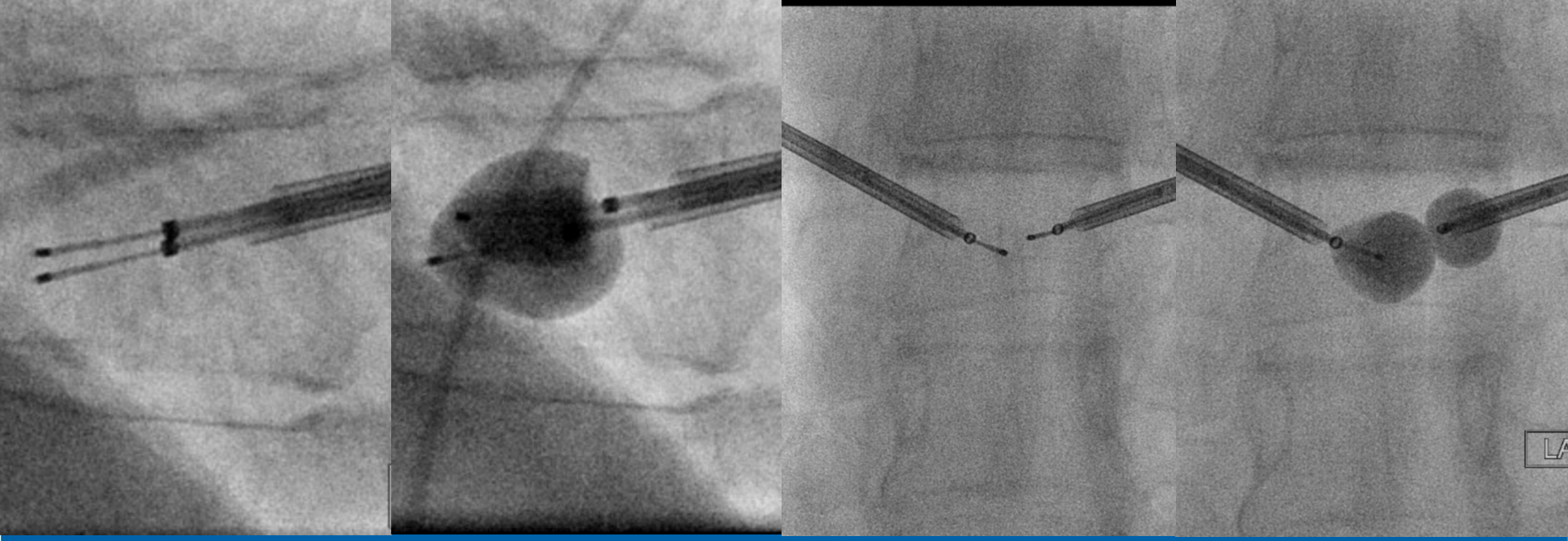
Data based on 70-degree angulation between probes

** Two distinct lesions were created around each electrode*



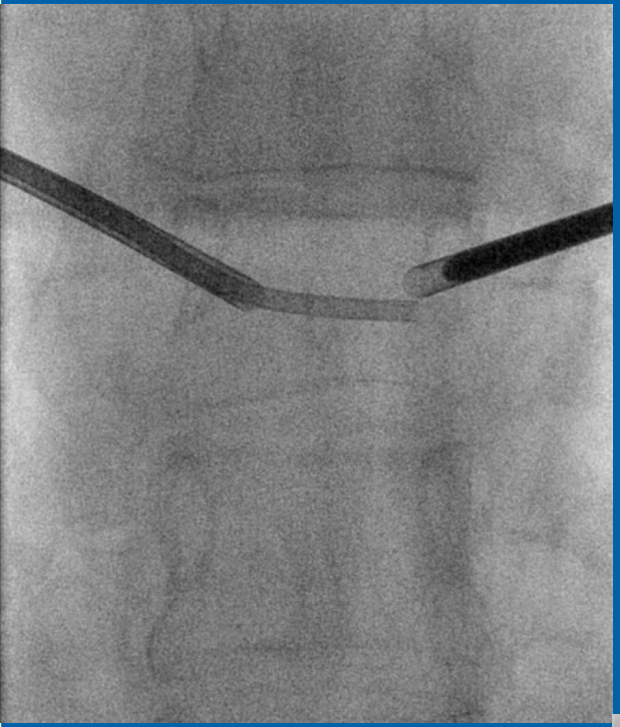


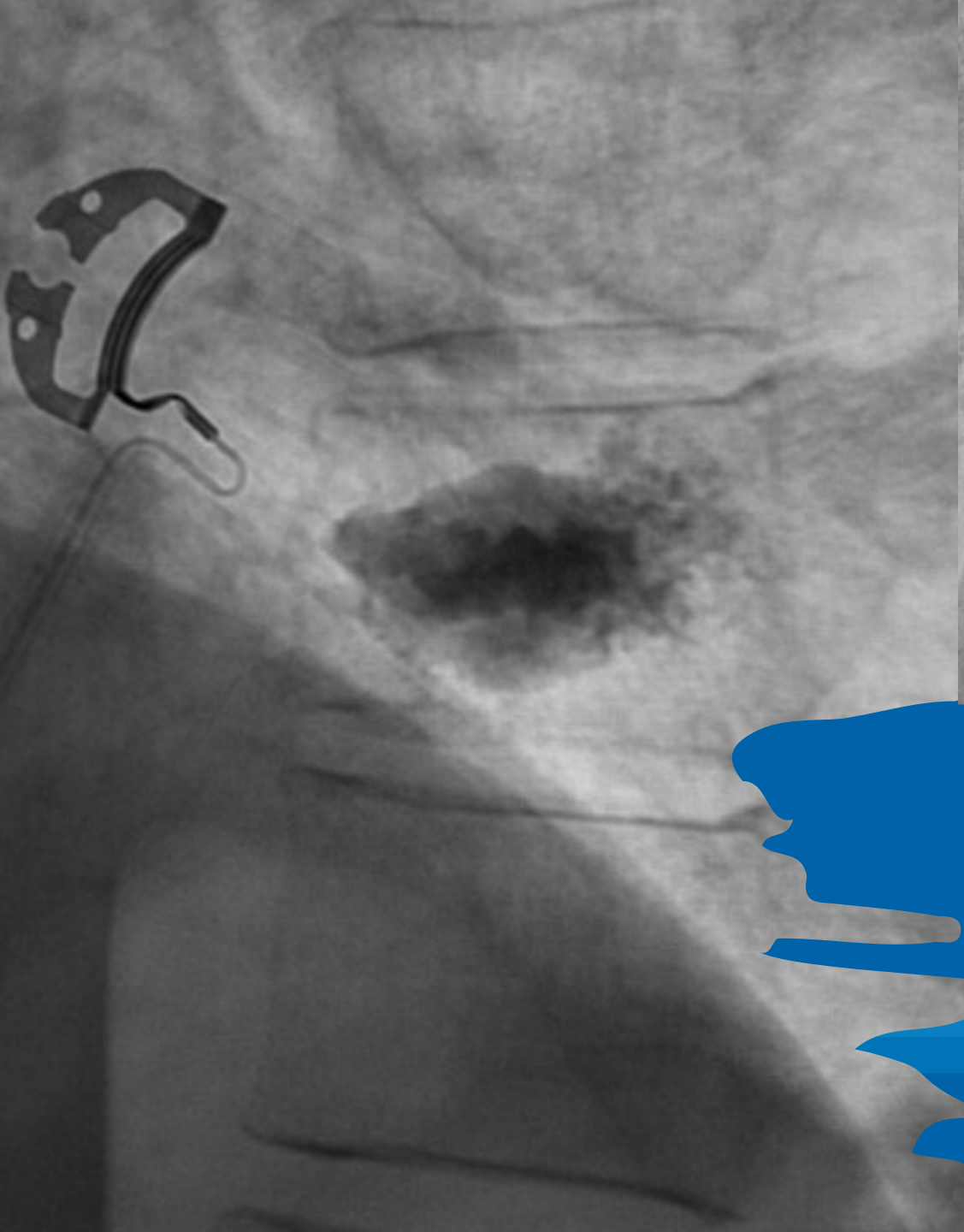
Ablation

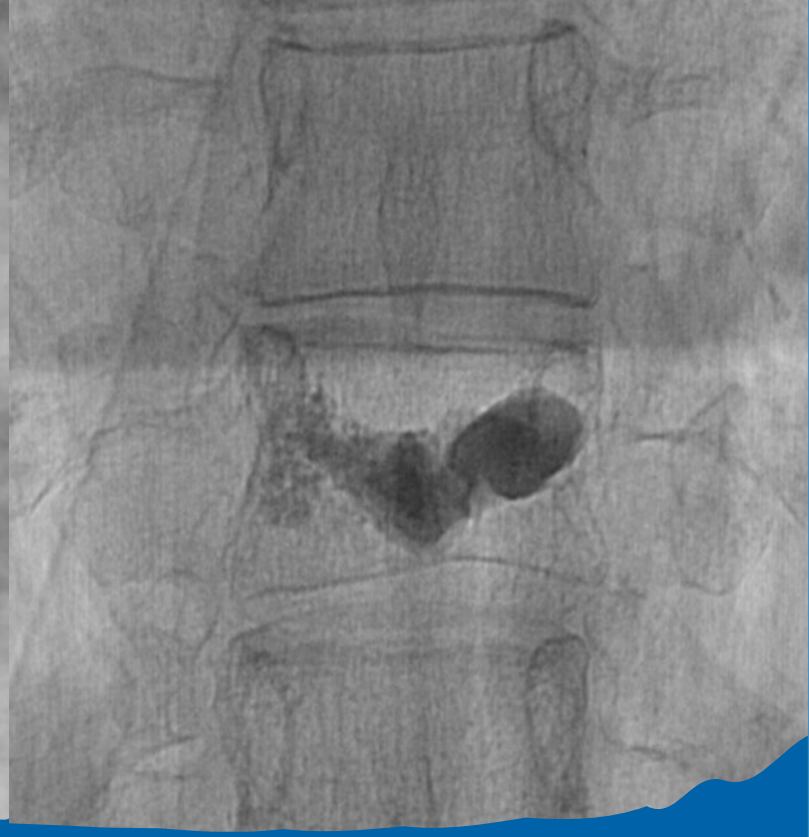


Kyphoplasty (Cavity creation)

- Compliant balloons
- Reach an endpoint (inferior endplate)



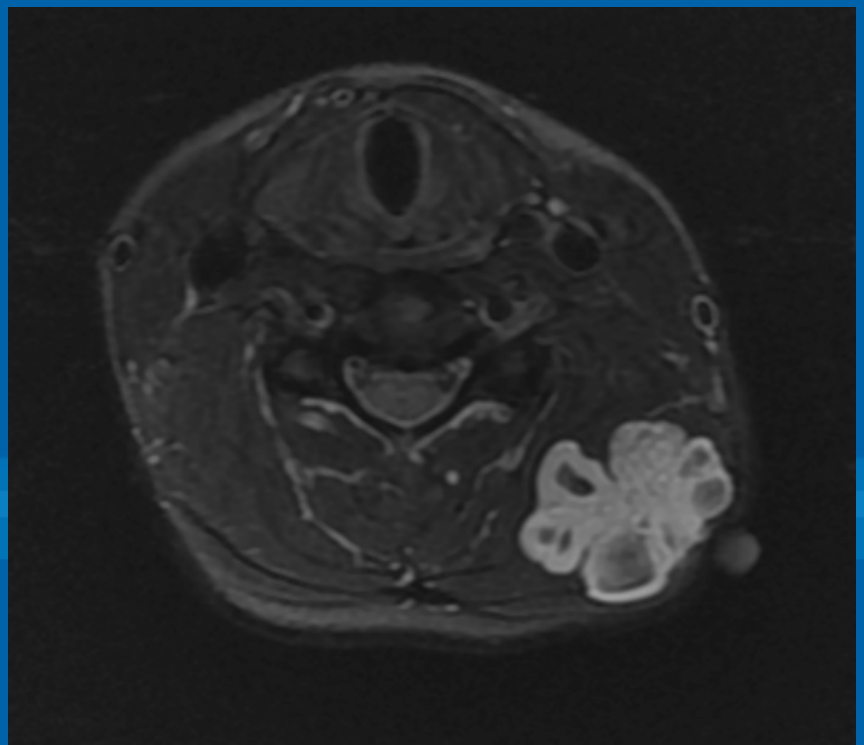


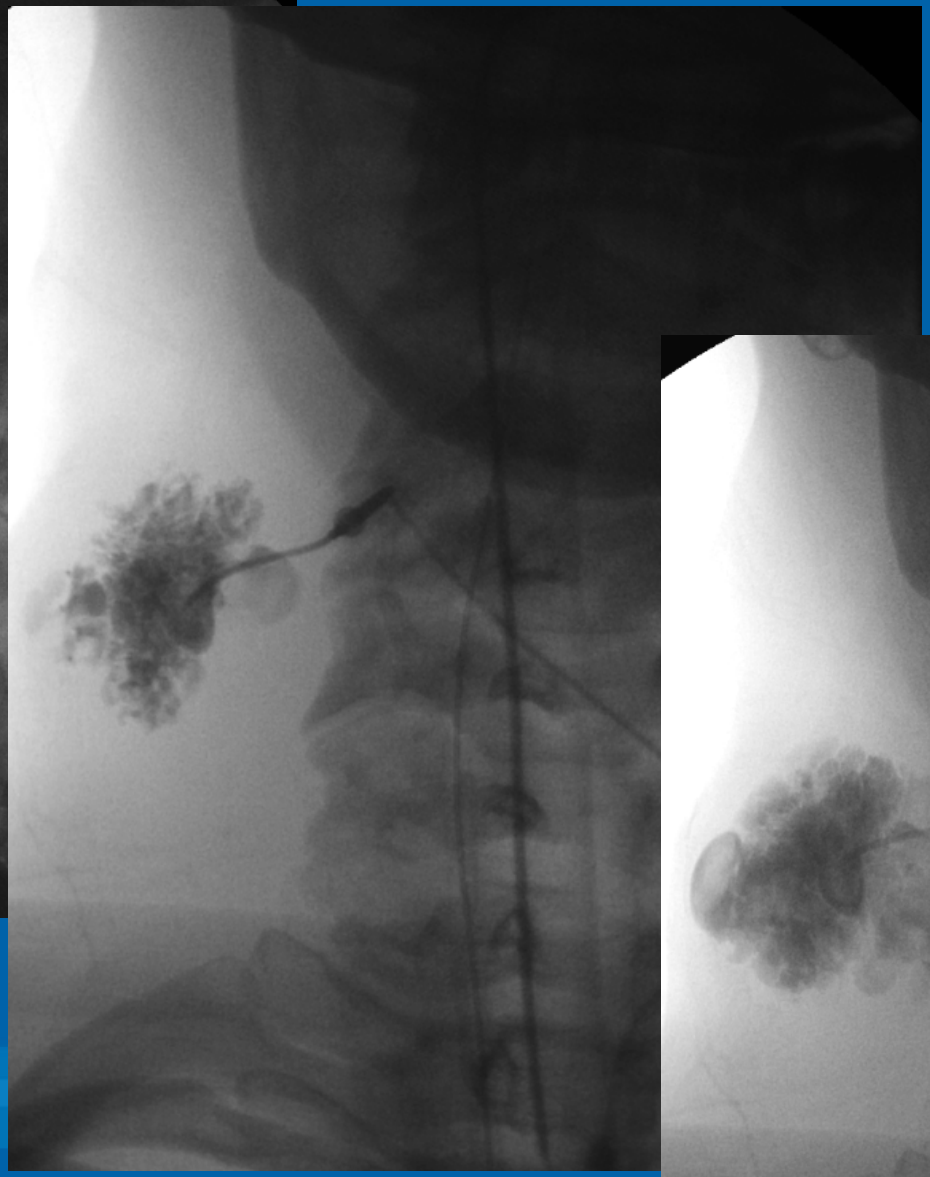


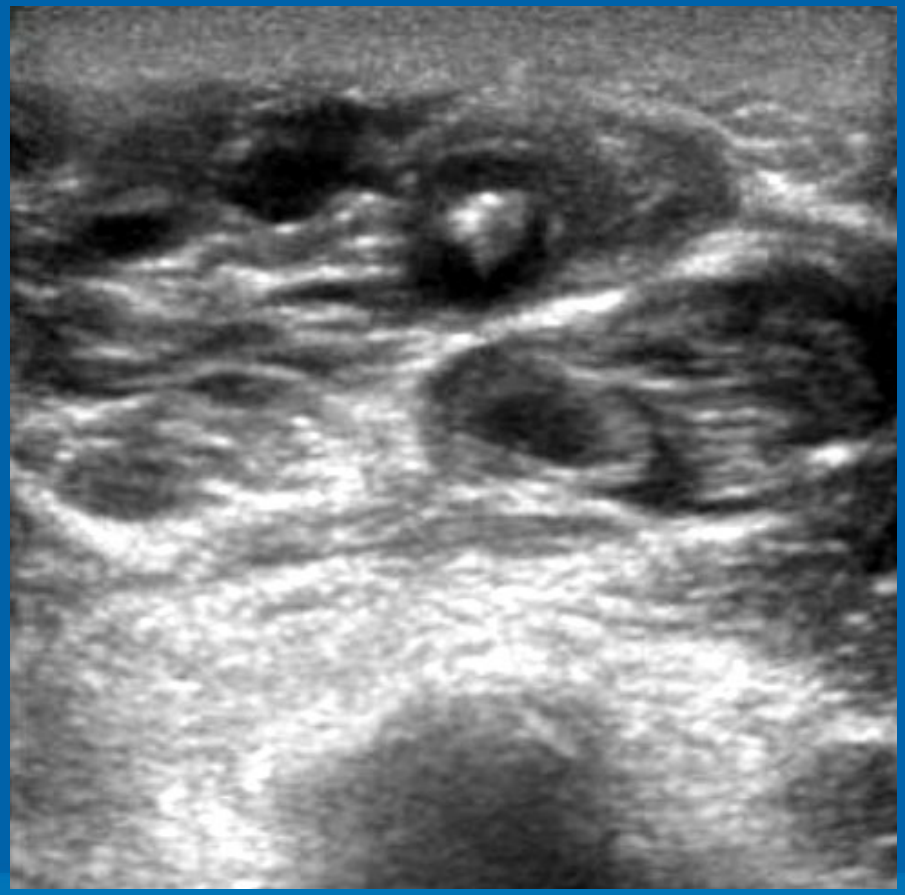
Final

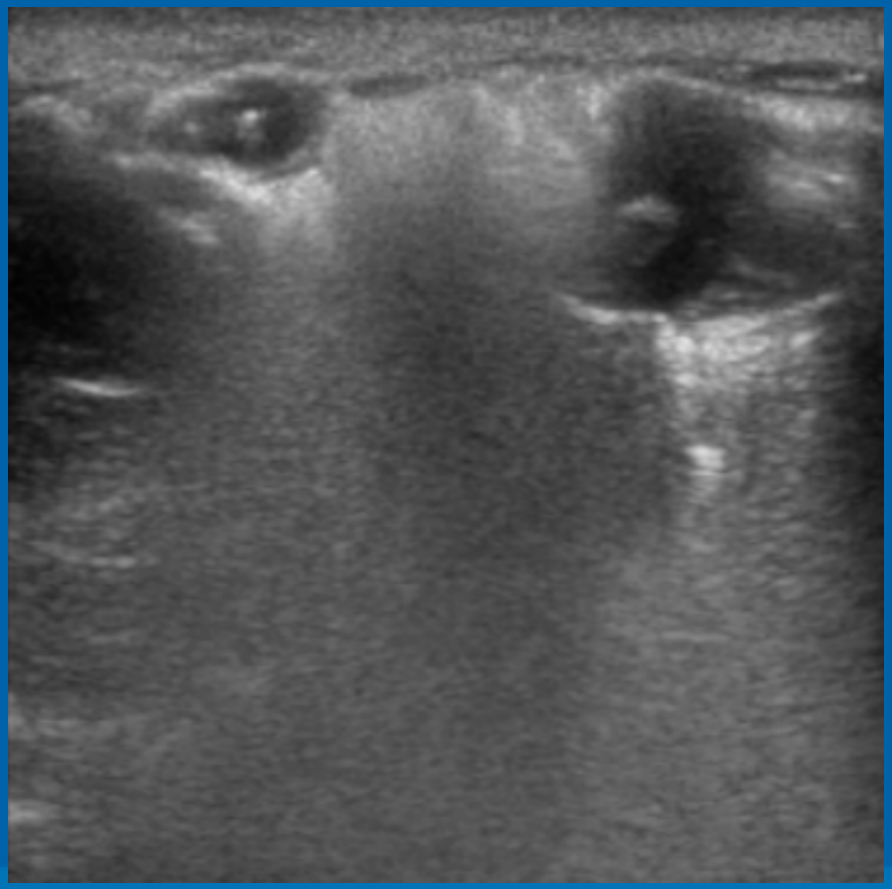
Lymphatic Interventions

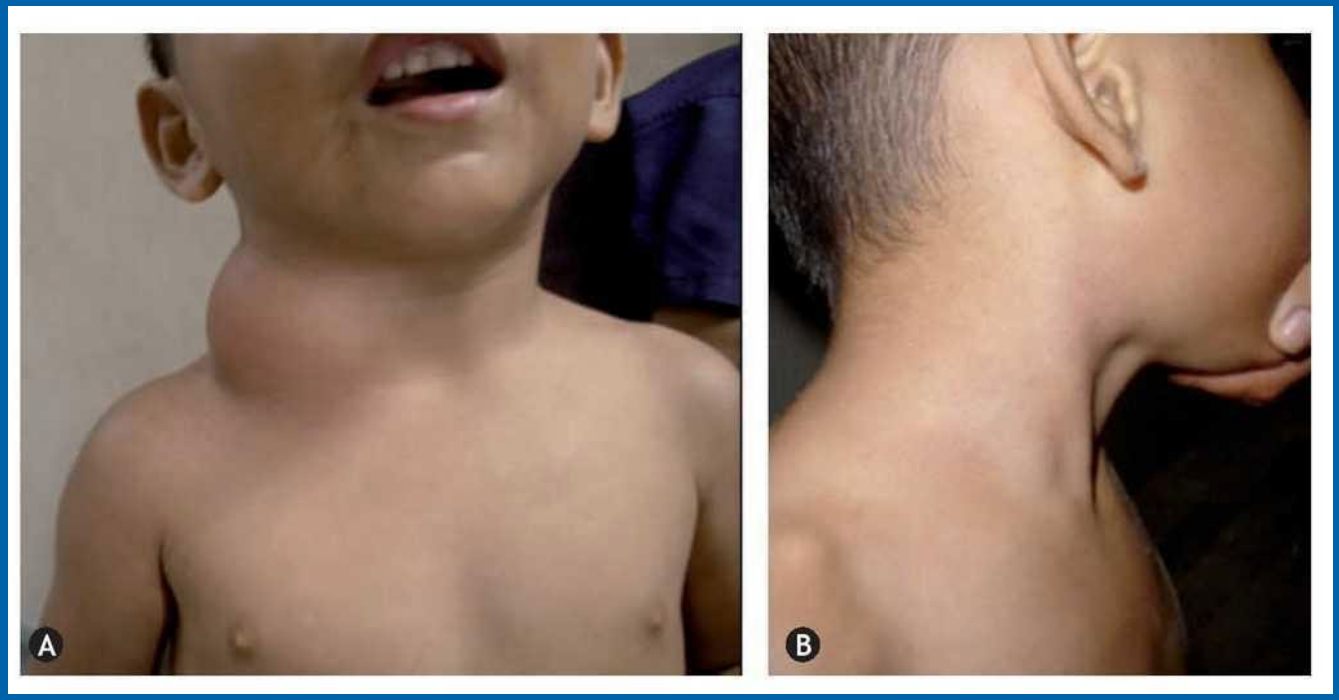
- Thoracic duct embolization
- Sclerotherapy for low flow vascular malformations (lymphatic/venous)

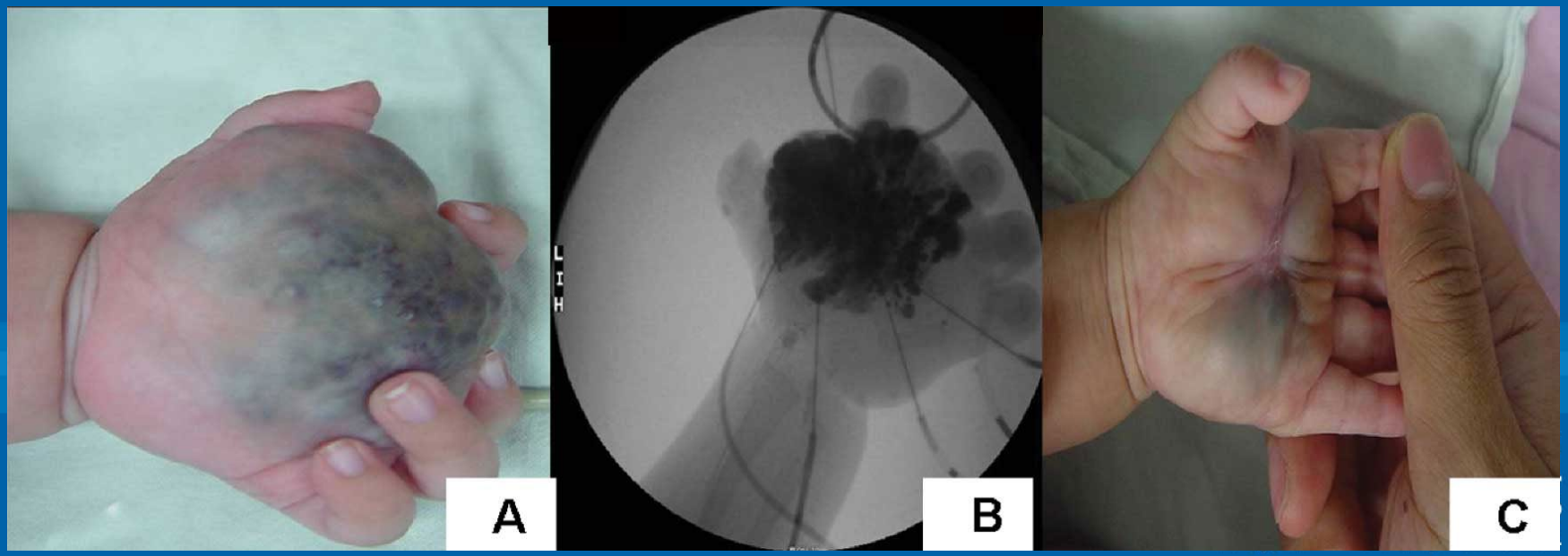









A
B


A
B
C

Thoracic Duct

Indications: high output chylothorax, chylous ascites

Outcomes:

- Technical success 80%, clinical success following TDE 90%

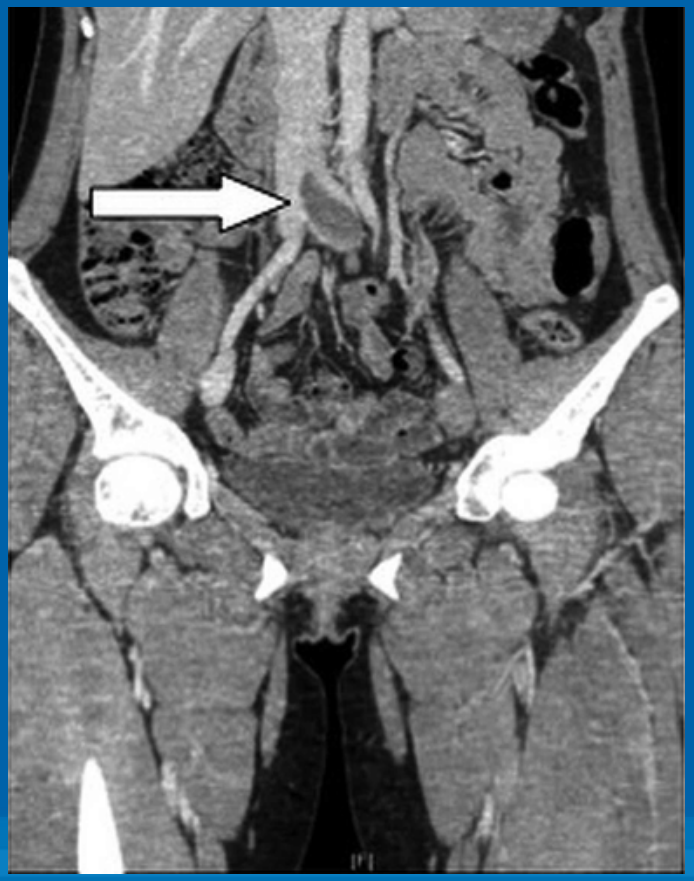
Complications:

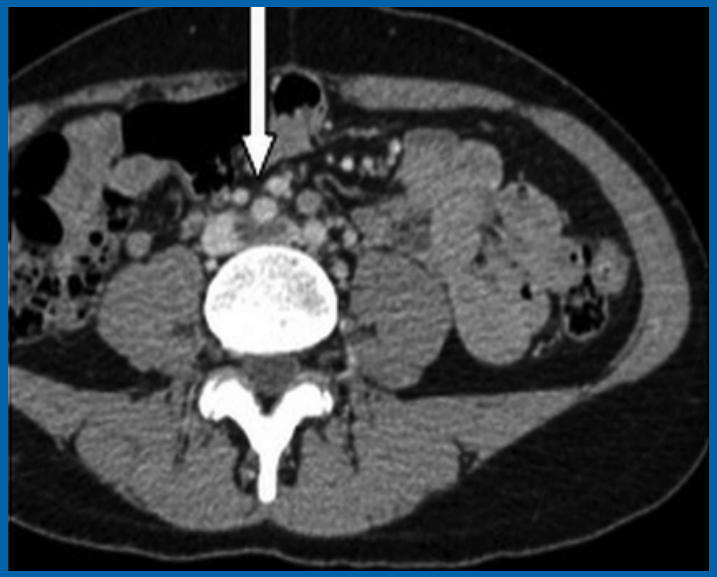
- No complications related to traversing visceral organs in literature
- No conversion of chylothorax to chylous ascites (dormant lymphovenous communications develop).
- ~ 10% develop lower extremity edema and ~10% develope diarrhea

Venous Disease

- DVT thrombolysis
- Pulmonary emboli
- IVC filters
- Iliocaval reconstruction
- Venous Insufficiency
  - EVLT/RFA venous insufficiency
  - Sclerotherapy
  - Spider veins

Case 1 37 y.o. F with 1yr hx of LLE swelling, heaviness, and pain p/w sudden worsening of LLE.





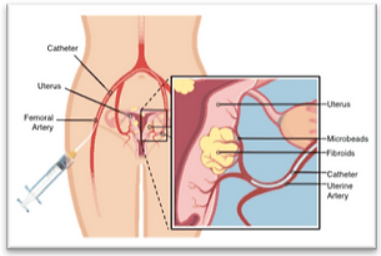
What is the diagnosis and how should this be managed?

Genitourinary Procedures

- Prostate artery embolization
- Fibroid embolization
- Post-partum uterine hemorrhage
- Varicocele embolization
- Pelvic congestion syndrome

Embolization (UFE)

Non-Surgical



An Interventional Radiologist occludes the blood vessels that feed the fibroids.

Fibroid Symptom Relief: As effective as other options

Invasiveness: Minimally invasive, performed with 1 small puncture

Hospital Stay: 0 to 1 day

Recovery Time: 1-2 Weeks

Safety: Minor side effects & complications more common

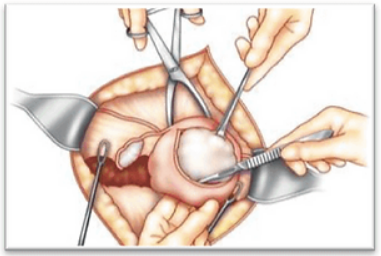
Ability to Become Pregnant: Pregnancy possible

Risk of Fibroid Recurrence: Less than 10% of cases at 2 years

Risk of Reintervention: ~12% of cases at 2 years

Myomectomy

Surgical



A surgeon selectively cuts out the fibroids while keeping the uterus intact.

Fibroid Symptom Relief: As effective as other options

Invasiveness: Major surgery, may require a blood transfusion

Hospital Stay: 1-3 days depending on surgical technique

Recovery Time: 2-6 weeks depending on the surgical technique

Safety: Major side effects & complications more common

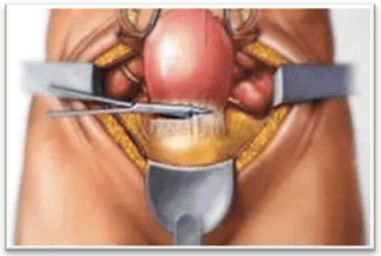
Ability to Become Pregnant: Pregnancy possible

Risk of Fibroid Recurrence: Less than 10% of cases at 2 years

Risk of Reintervention: ~8% of cases at 2 years

Hysterectomy

Surgical



A surgeon completely removes part or all of the uterus, taking the fibroids with it.

Fibroid Symptom Relief: As effective as other options

Invasiveness: Major surgery, may require a blood transfusion

Hospital Stay: 1-3 days depending on surgical technique

Recovery Time: 2-6 weeks depending on the surgical technique

Safety: Major side effects & complications more common

Ability to Become Pregnant: No

Risk of Fibroid Recurrence: None

Risk of Reintervention: ~7% of cases at 2 years

References: [1] Gupta et al. (2014). Uterine artery embolization for symptomatic uterine fibroids (Review). *Cochrane Library*, (5). [2] de Bruijn, A. M., Ankum, W. M., Reekers, J. A., Birnie, E., van der Kooij, S. M., Volkers, N. A., & Hehenkamp, W. J. K. (2016). Uterine artery embolization vs hysterectomy in the treatment of symptomatic uterine fibroids: 10-year outcomes from the randomized EMMY trial. *American Journal of Obstetrics and Gynecology*, *215*(6), 745.e1-745.e12. [3] Mara, M., Maskova, J., Fucikova, Z., Kuzel, D., Belsan, T., & Sosna, O. (2008). Midterm clinical and first reproductive results of a randomized controlled trial comparing uterine fibroid embolization and myomectomy. *CardioVascular and Interventional Radiology*, *31*(1), 73–85. [4] de Bruijn, A. M., Ankum, W. M., Reekers, J. A., Birnie, E., van der Kooij, S. M., Volkers, N. A., & Hehenkamp, W. J. K. (2016). Uterine artery embolization vs hysterectomy in the treatment of symptomatic uterine fibroids: 10-year outcomes from the randomized EMMY trial. *American Journal of Obstetrics and Gynecology*, *215*(6), 745.e1-745.e12. [5] Davis, M. R., Soliman, A. M., Castelli-Haley, J., Snabes, M. C., & Surrey, E. S. (2018). Reintervention Rates After Myomectomy, Endometrial Ablation, and Uterine Artery Embolization for Patients with Uterine Fibroids. *Journal of Women's Health (2002)*, *27*(10). [6] McLucas, B., Voorhees, W. D., & Elliott, S. (2016). Fertility after uterine artery embolization: A review. *Minimally Invasive Therapy and Allied Technologies*, *25*(1), 1–7.

Future Directions

- Bariatric Embolization
  - Particle/coil embolization of left gastric artery -> suppression of the ghrelin-producing cells in the stomach
  - Trials: GET LEAN, BEAT, NCT02786108
- Painful MSK Conditions
  - Ostoarthritis, frozen shoulder, tendiopathy
  - Target inflammatory angiogenesis that contributions to chronic pain by enabling growth of new unmyelinated sensory nerves
  - Embo with imipenemcilastin and microspheres

Future Directions

- Percutaneous AVF creation
  - Uses RF catheter to create fusion channel between arterial/venous wall.
  - NEAT trial: 98% effective, 87% primary efficacy, 69% patency at 1 year

- HIFU
- Immune & Stem Cell Therapies

Thank You!

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