The role of interventional radiology in traumatic patients

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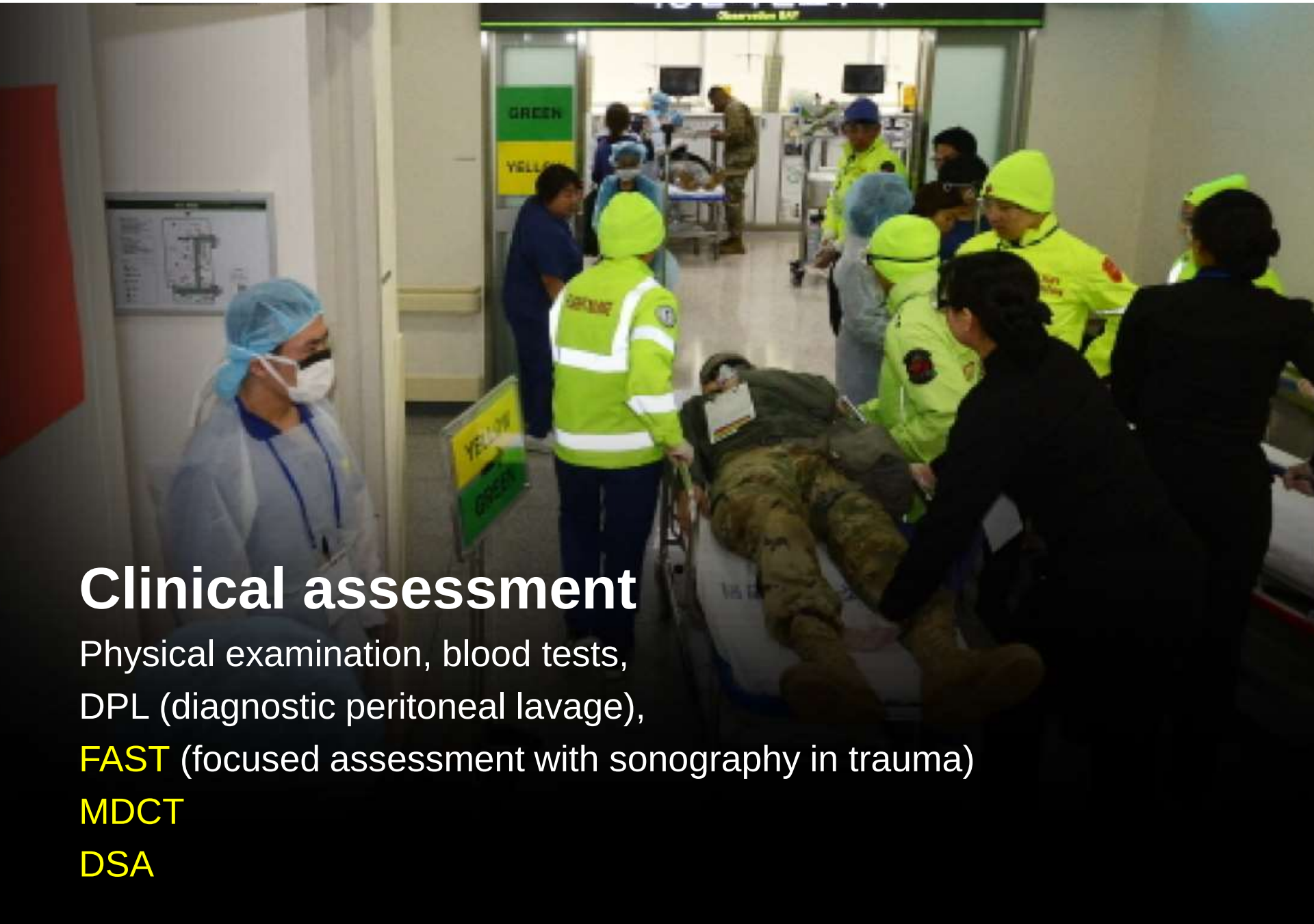
Intervention in trauma center

- Bleeding control : Blunt trauma of solid organ
- Blunt traumatic aortic injury
- Vascular injuries

Blunt trauma

- **원인**
  교통사고 / 추락사고 (Fall injury)
- **기전**
  감속손상 Deceleration (shearing force)
  압착손상 Crushing injury
  외부압박 External compression
- **Frequently injured organs**
  Spleen
  Liver
  Bowel/mesentery
  Pancreas
  Adrenal glands



Clinical assessment

Physical examination, blood tests,

DPL (diagnostic peritoneal lavage),

FAST (focused assessment with sonography in trauma)

MDCT

DSA

Embolization

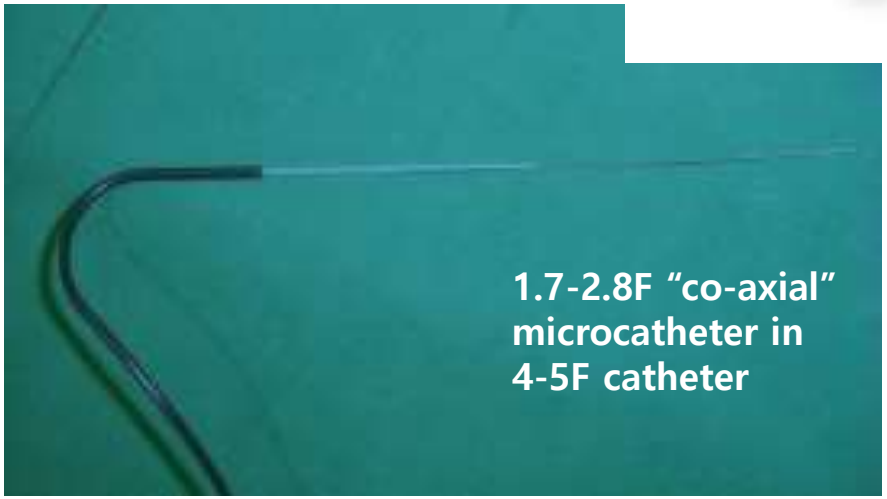
Standard of care for hemodynamically stable patients

Advantages of embolization

Less hospital cost, earlier discharge, fewer postoperative complications, reduced transfusion rate

Endovascular Procedure

- Strategy
  - Anatomical location: terminal branch vs major artery injury
  - Type of procedure: stent-graft vs embolization
- Embolization technique
  - Superselective, co-axial technique
  - Avoid non-target embolization



Terminal artery embolization

Coil

Gelfoam (slurry)

PVA particle

Glue (N-butyl cyanoacrylate; NBCA)

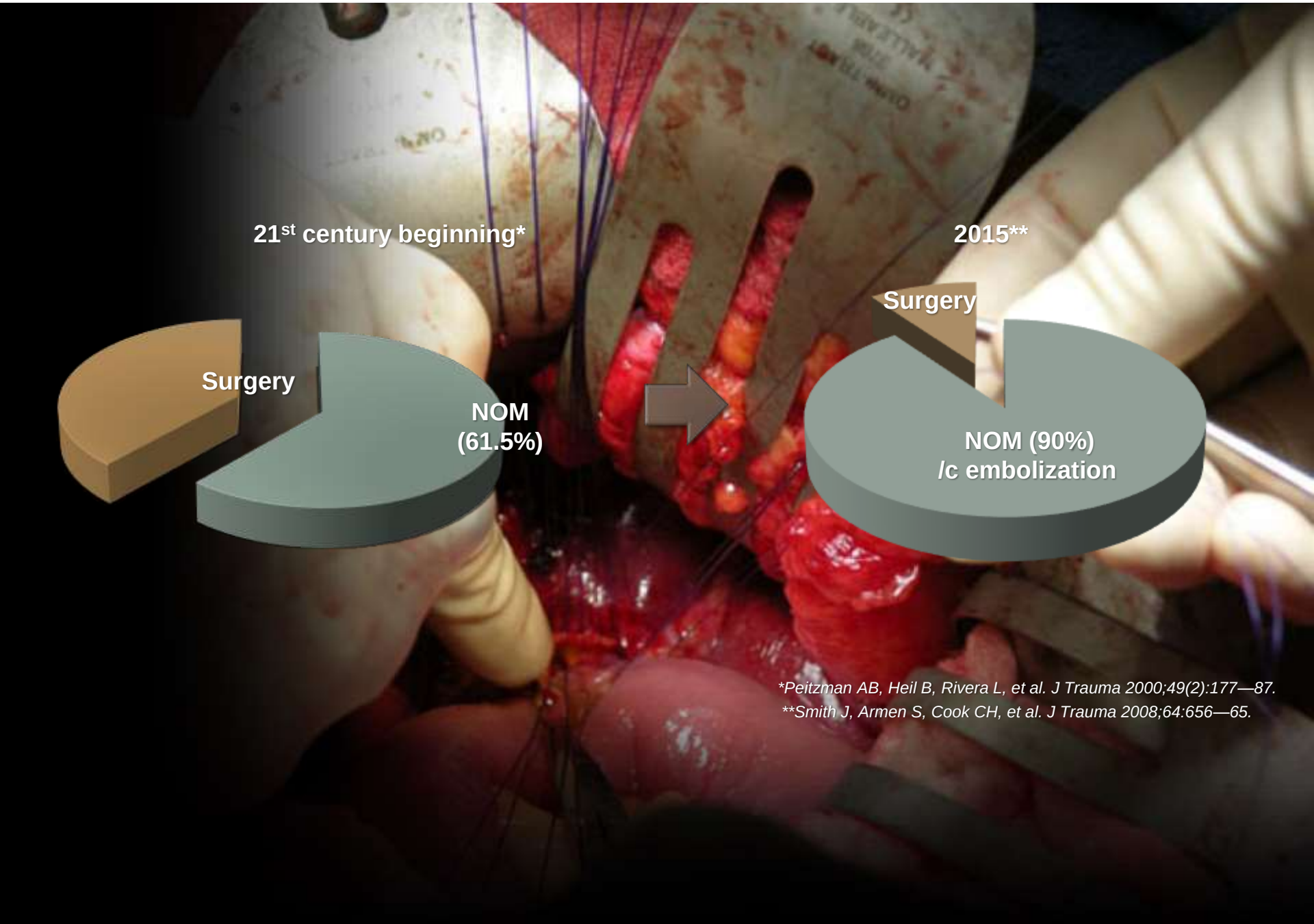
Spleen 비장

- 복부둔상 환자에서 가장 흔하게 손상을 받는 복강내 장기
- 빈도: ~40%
- 비장의 수술적 절제 후 면역기능 저하, 패혈증 등 합병증에 대한 보고가 많아지면서 점차 비수술적 치료가 각광 받게 됨

Kristinsson et al. (2014): a cohort study, 27 years follow up, 8149 patients
Splenectomized patients had an increased risk of certain solid tumors (rate ratios =1.3–1.9): liver, colon, pancreatic, and lung cancer; hematologic malignancies (1.8–6.0): non-Hodgkin lymphoma, Hodgkin lymphoma, and any leukemia.

Kristinsson SY et al. Haematologica 2014;99:392–398

- 과거 비수술적 치료(NOM: non-operative management)의 개념과 달리 필요시 transcatheter embolization을 보조적으로시행하면서 NOM의 성적을 향상시킬 수 있음



*Peitzman AB, Heil B, Rivera L, et al. J Trauma 2000;49(2):177—87.

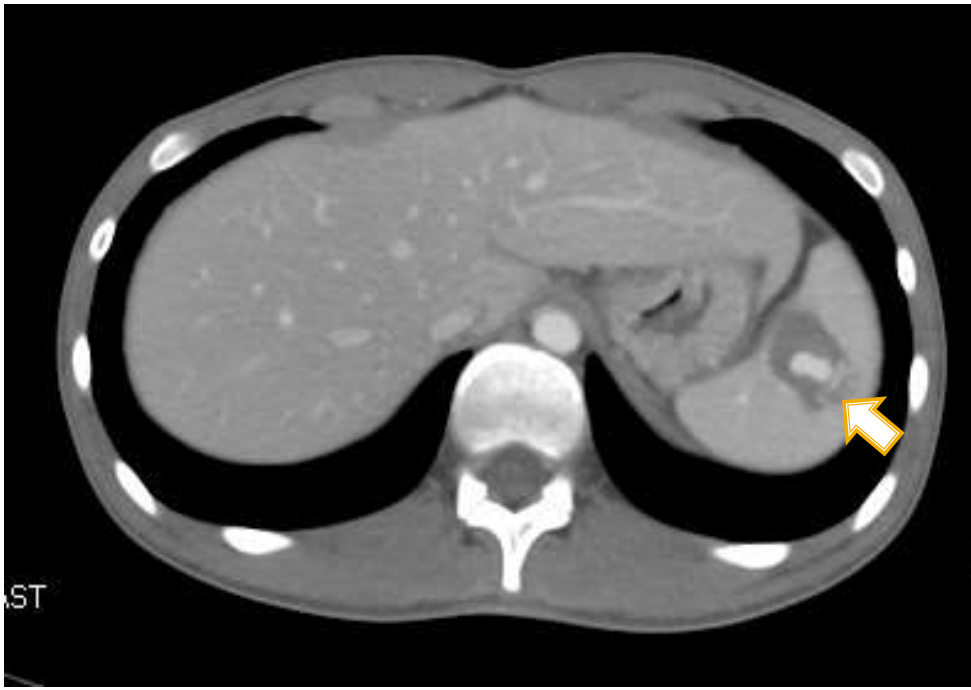
**Smith J, Armen S, Cook CH, et al. J Trauma 2008;64:656—65.

M/16

Blood pressure 115/65, hgb/hct 12.9/37.8

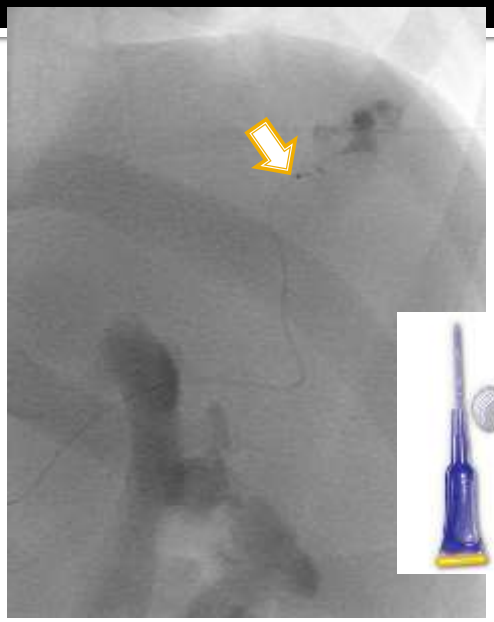
CT: intraparenchymal Extravasation

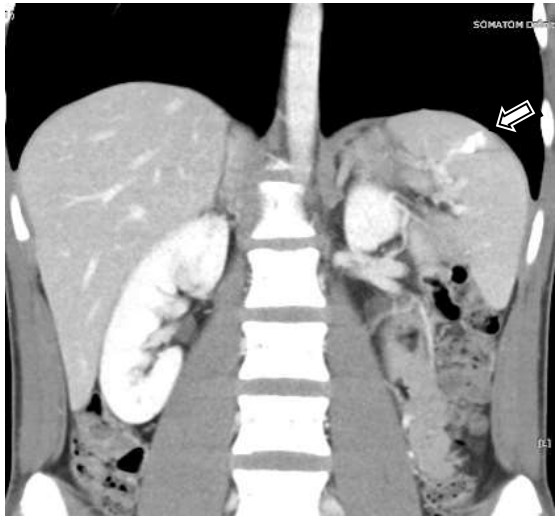
Initial



10 days later

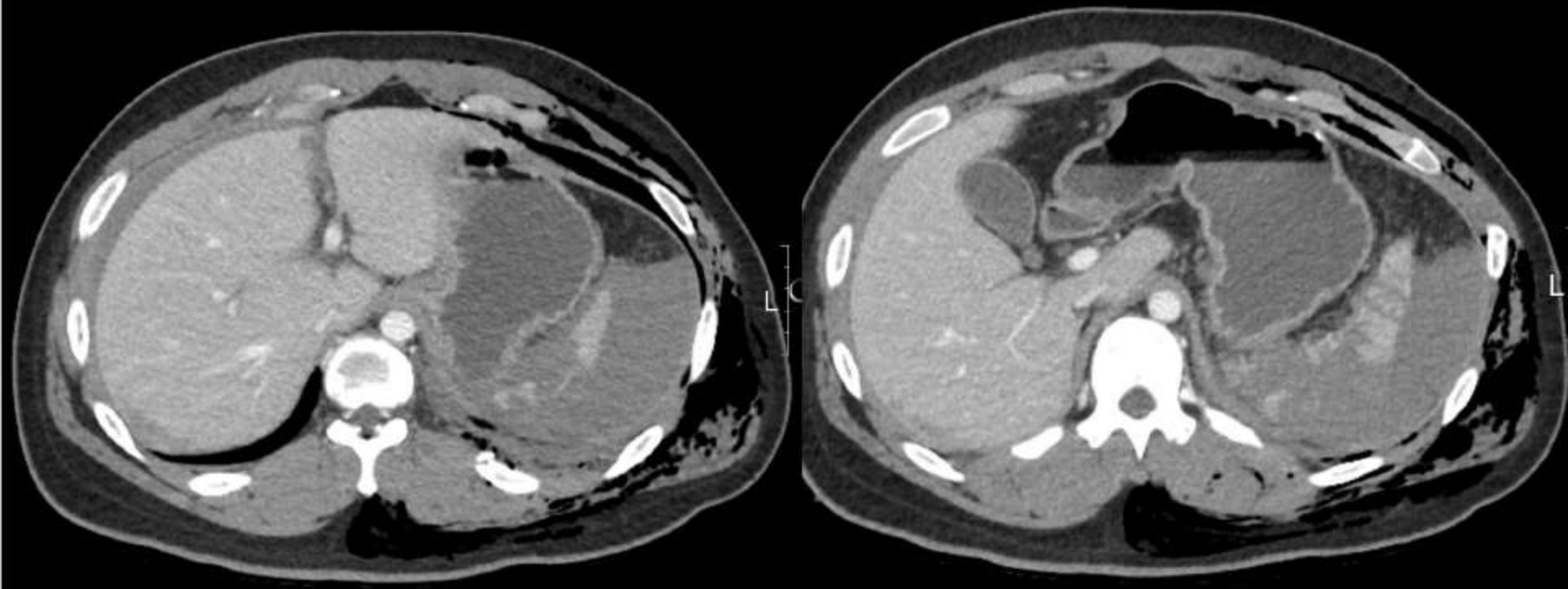
Pseudoaneurysm: selective embolization





Trauma Intervention for Splenic Injury

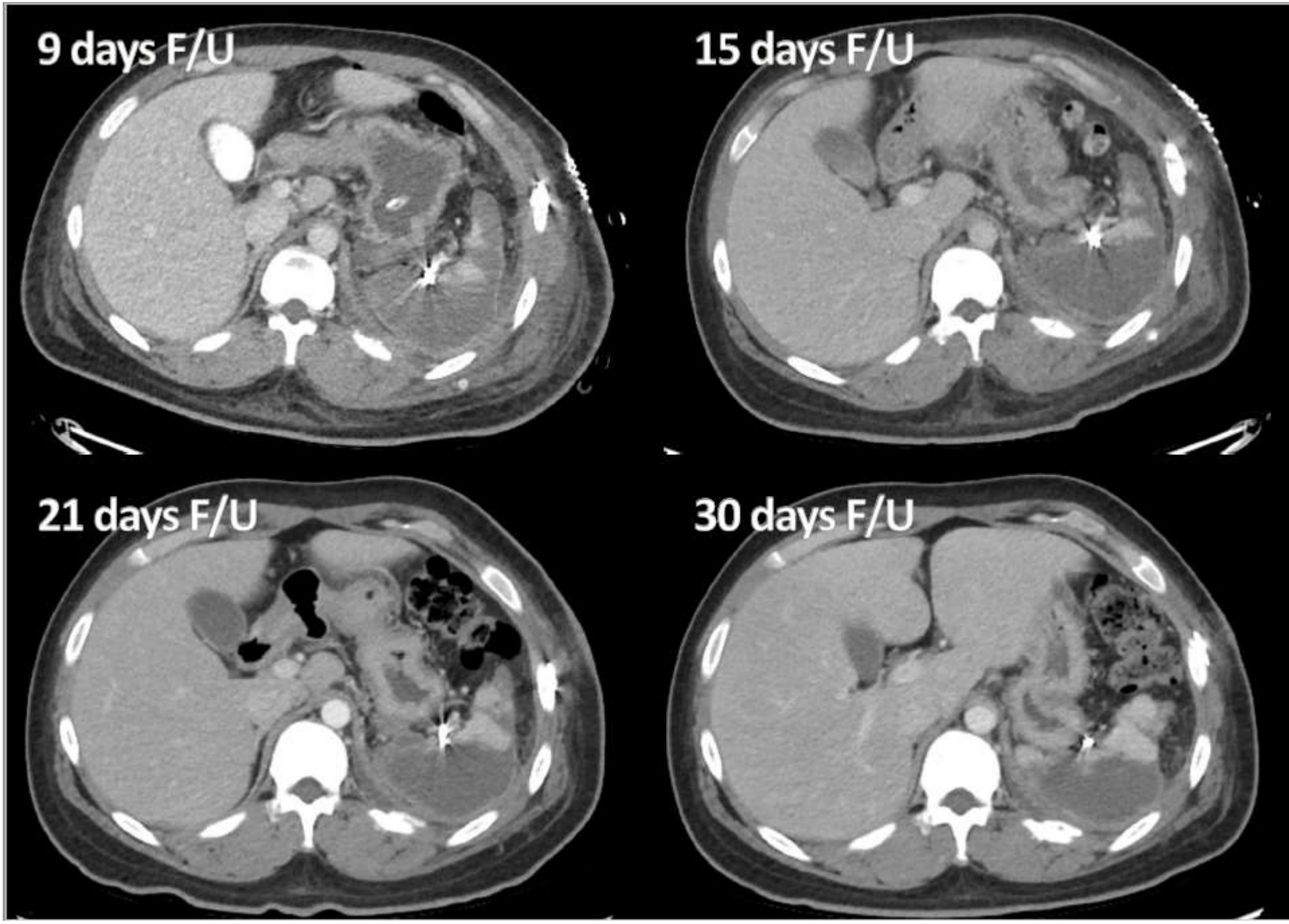
M/24, Motor vehicle collision

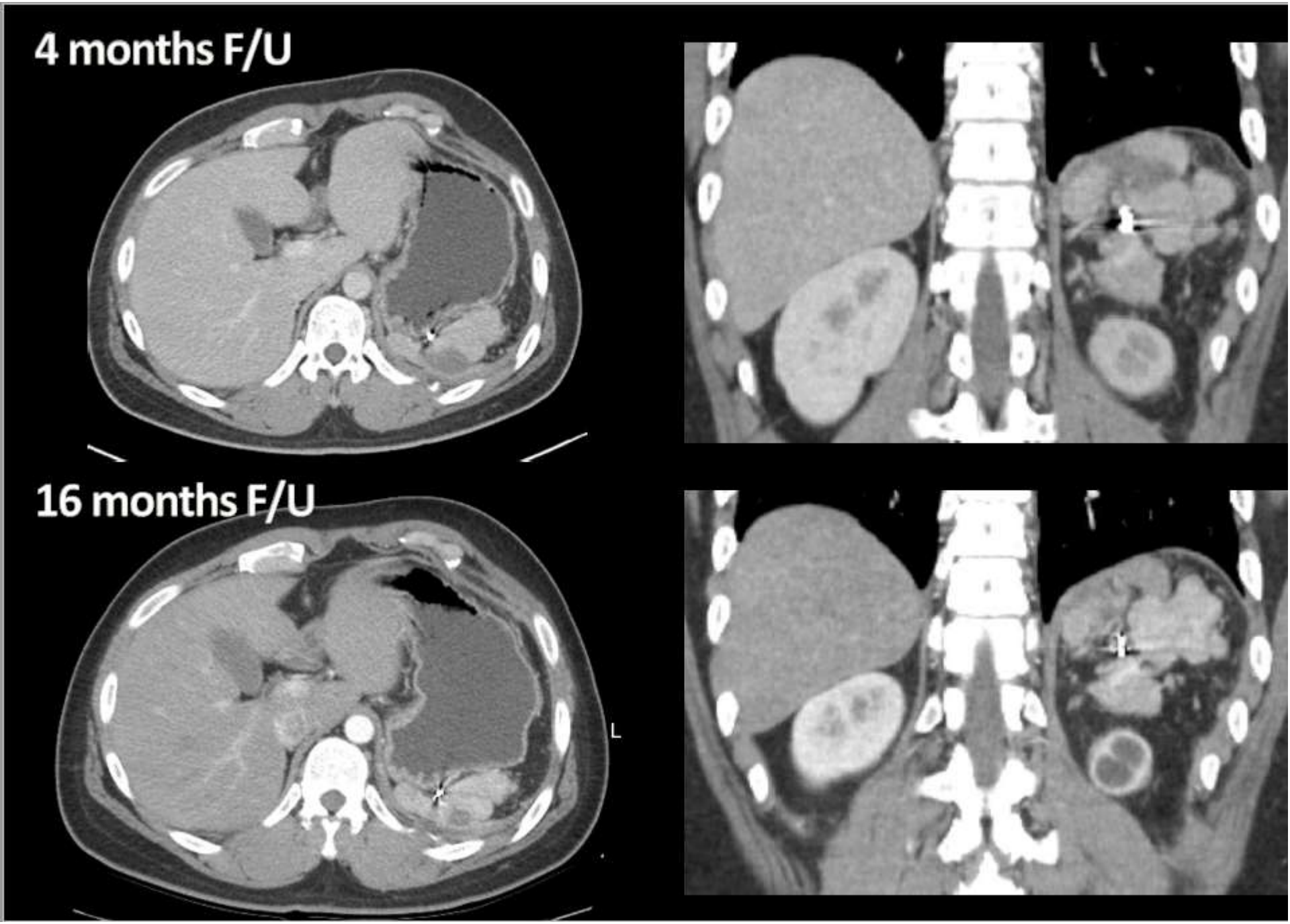


Shattered spleen, Contrast extravasation, Perisplenic hematoma
Initial BP 90/60mmHg, 80/min, Hb 9.4g/dL

Courtesy of Dr Jeon CH

Gelatin sponge particle, microcoil embolization

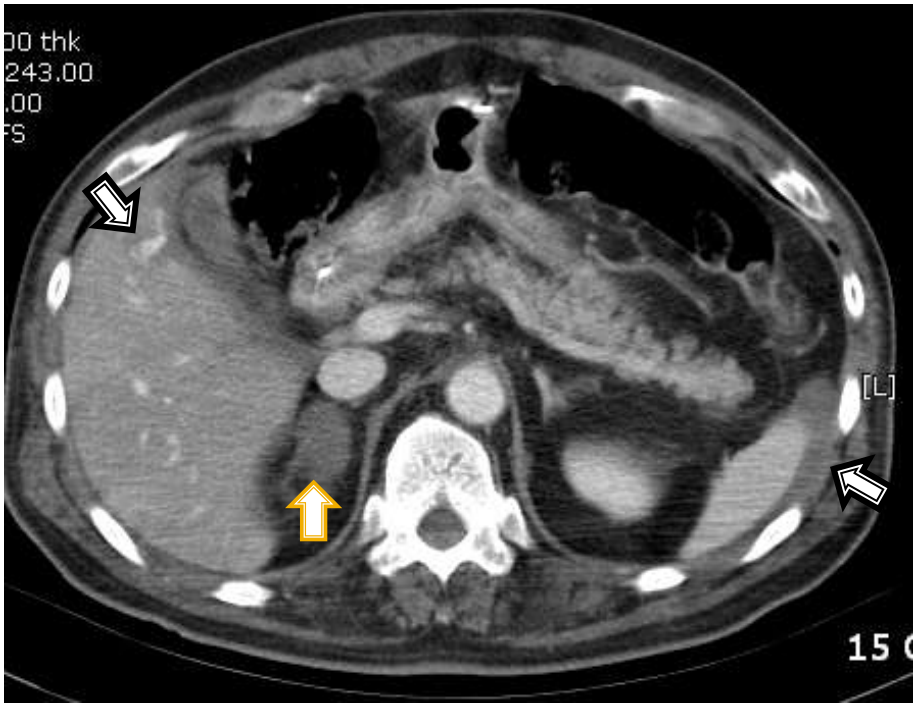

9 days F/U
15 days F/U
21 days F/U
30 days F/U


4 months F/U
16 months F/U
L

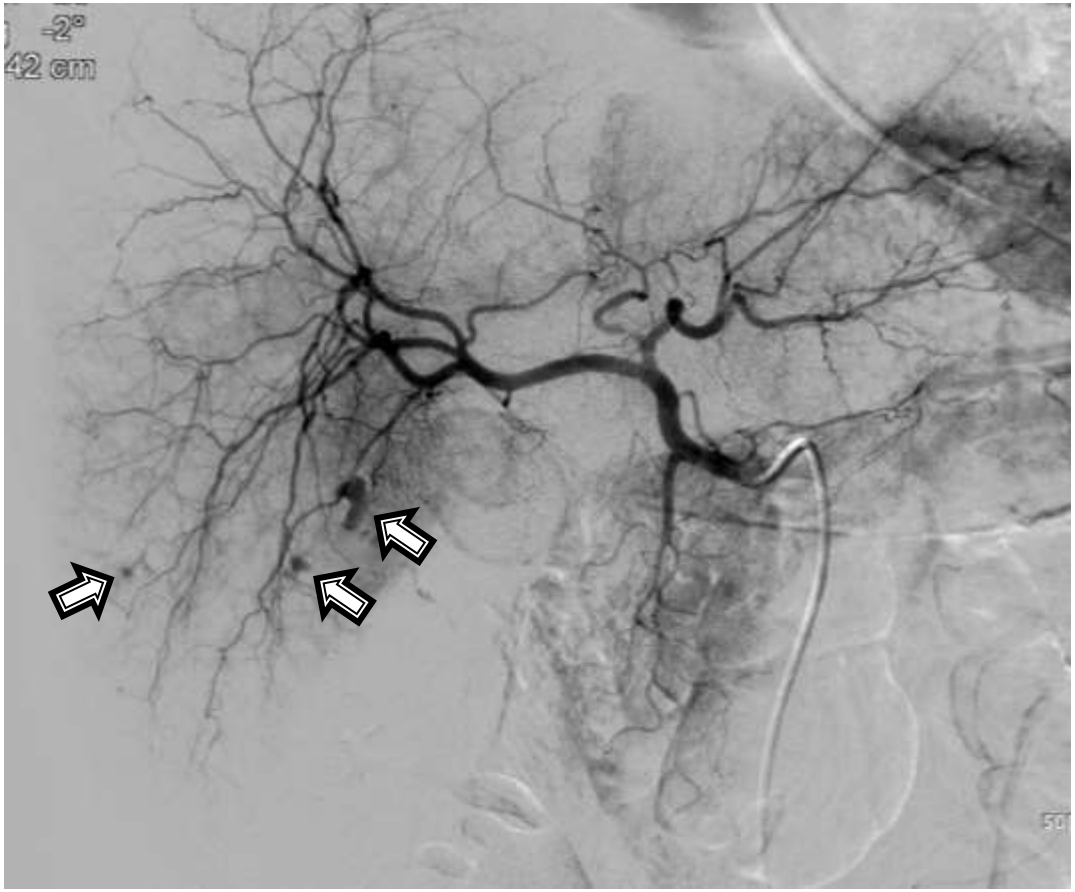
Liver

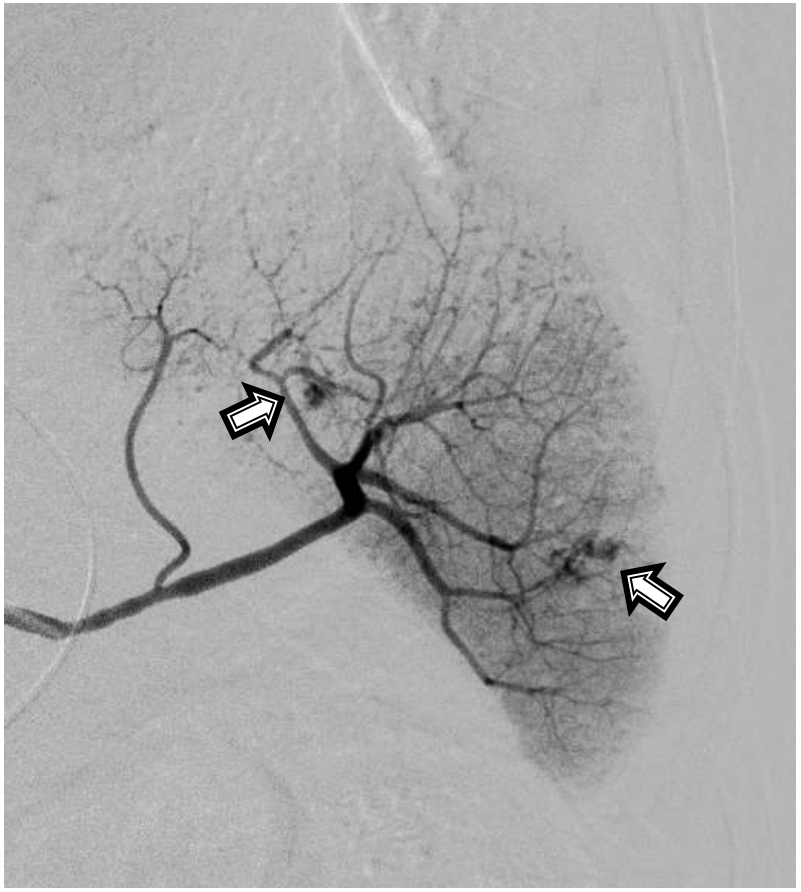
- Spleen 다음으로 두 번째로 흔하게 손상 받는 복부내 장기
- 빈도: 25-40%
- 간우엽 > 간좌엽 손상
- 간 손상 환자의 70-80%는 손상이 심하지 않거나 출혈이 멎어 있어 수술적 치료가 필요 없음
- 큰 혈관 또는 간문부 근처 혈관 손상이 있는 경우 출혈이 멈추지 않을 수 있음

Polytrauma M/46 Decreasing Hgb/Hct



DSA





Selective embolization

Gelfoam

Follow-up CT

1 day later

2 months later

Complications

- Liver has dual supply but ischemic complication can occur
  - Associated portal vein injury?

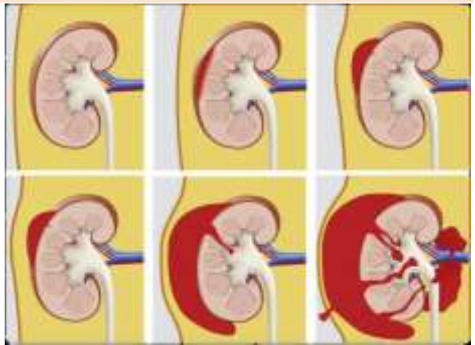
- Misselbeck et al. (*J Trauma.* 2009;67:769-773)
  - Parenchymal necrosis requiring debridement: 16%
  - Gallbladder ischemia needing cholecystectomy: 16%

Kidney 신장

- 관통상 > 둔상(국가/지역에 따라 빈도의 차이가 있음)
- 간 또는 비장의 손상이 동반된 경우가 많다
- 후복강에 위치하고 있어 수술적 치료를 요하는 경우는 많지 않다
- Shattered kidney를 제외하고 대부분 비수술적 치료로 충분하며 근래 들어 색전술의 역할이 부각됨

AAST (American Association for the Surgery of Trauma)

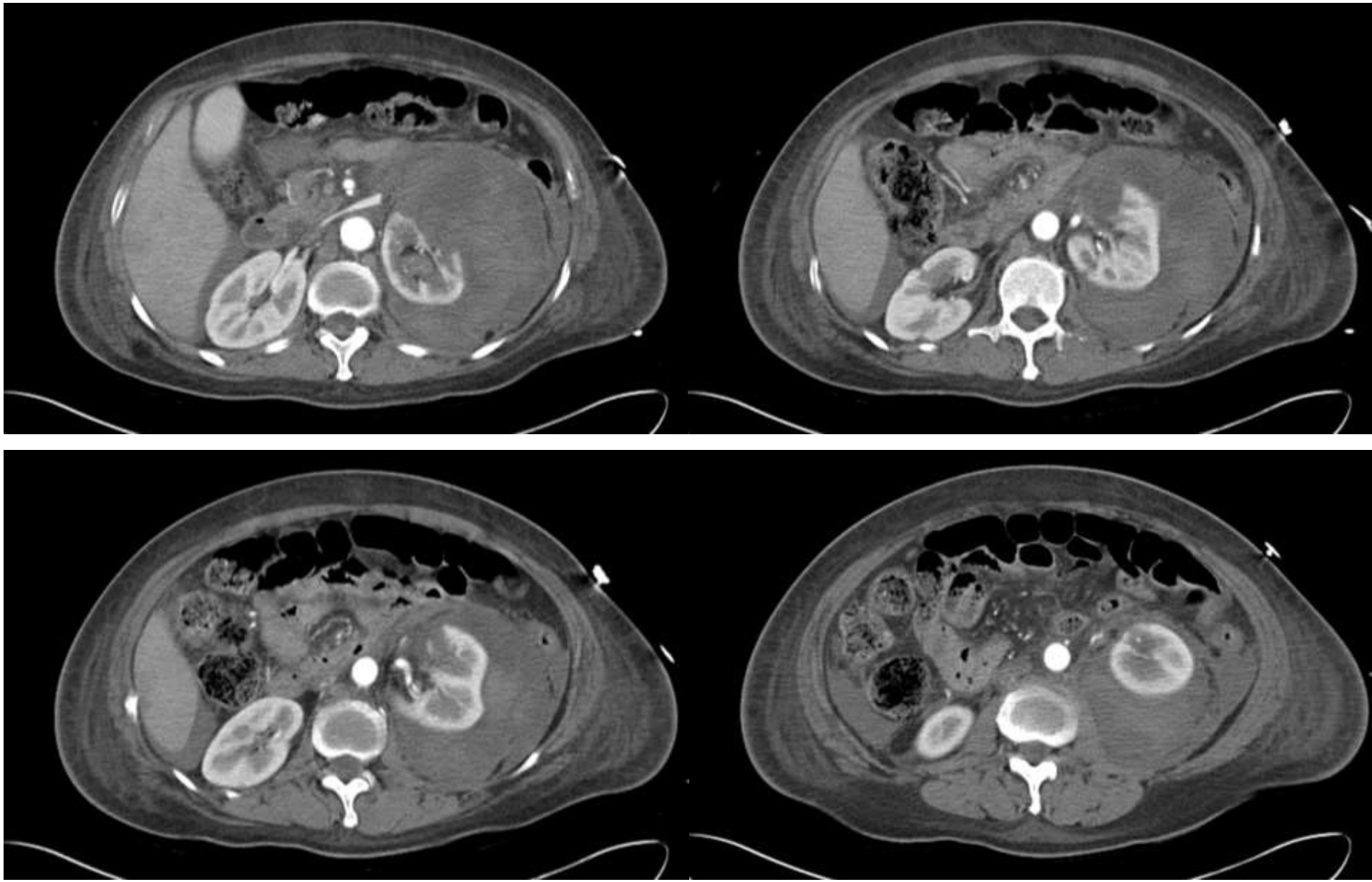
Grade (AAST)	Laceration	Hematoma	Vascular	Common treatment
Grade I	None	Subcapsular hematoma		Conservative
Grade II	Superficial (<1cm)	Non-expanding perirenal hematoma		Conservative
Grade III	>1cm laceration, intact collecting system			Endovascular
Grade IV	Extension through cortex/medulla/collecting system	Expanding subcapsular hematoma compressing kidney	Main renal A or V injury with contained hemorrhage	Endovascular
Grade V	Shattered kidney		Avulsion, thrombosis ("devascularization")	Immediate surgery

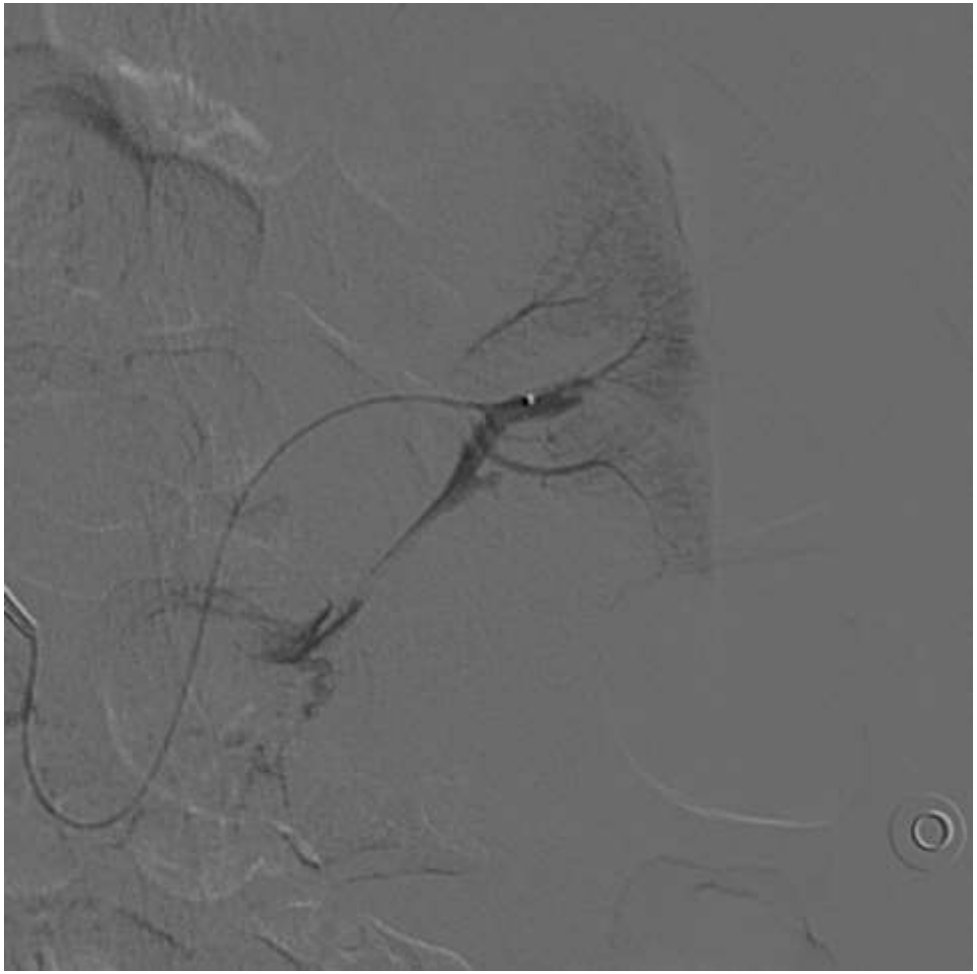


Outcome of embolization

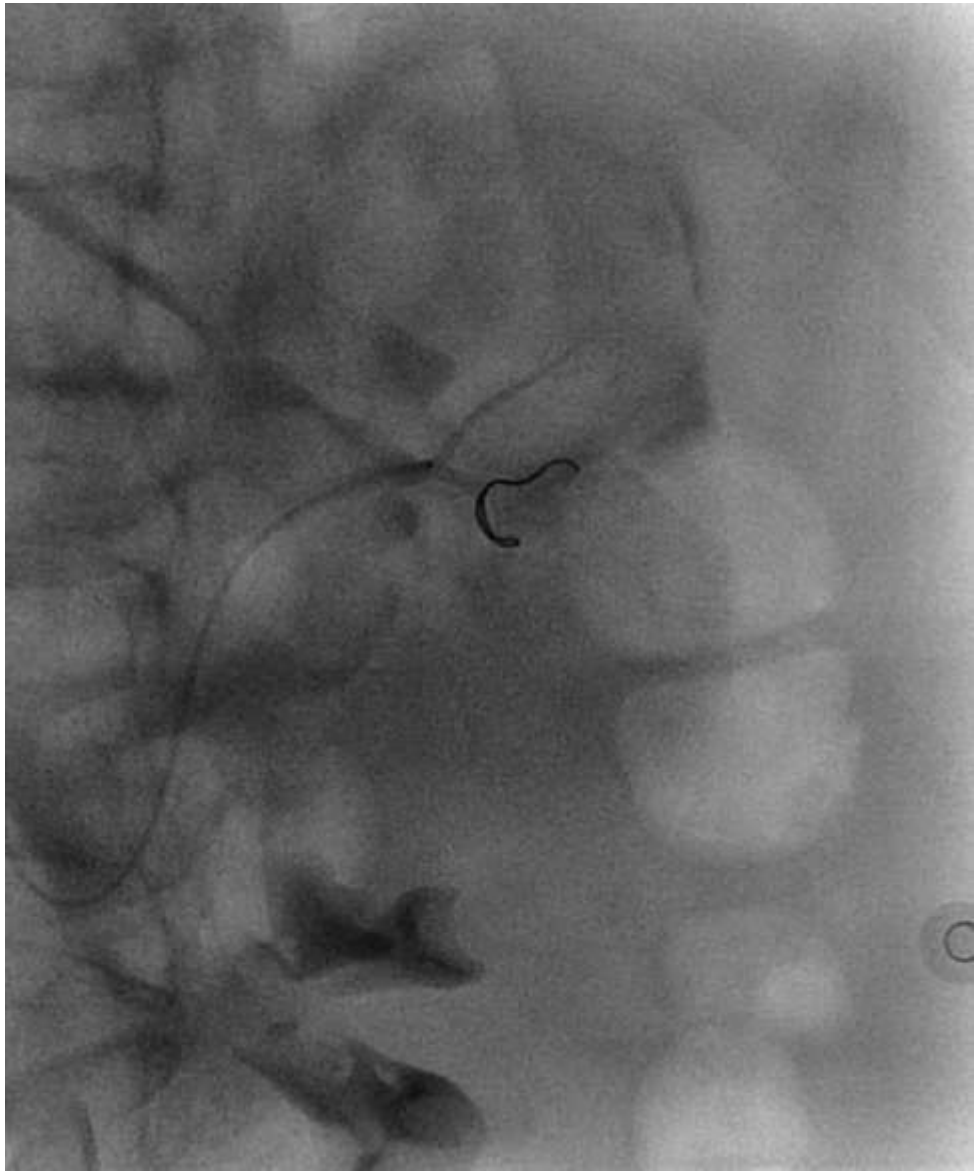
- Hemostasis
  - Technical success: 90%
  - Clinical success: 79%
- Complications
  - Renal infarction:
    - Least forgiving organ (irreversible nephron loss)
    - Superselective technique is important!
  - Acute tubular necrosis:
    - Hypovolemic shock + embolization-related ischemia + contrast-induced nephropathy

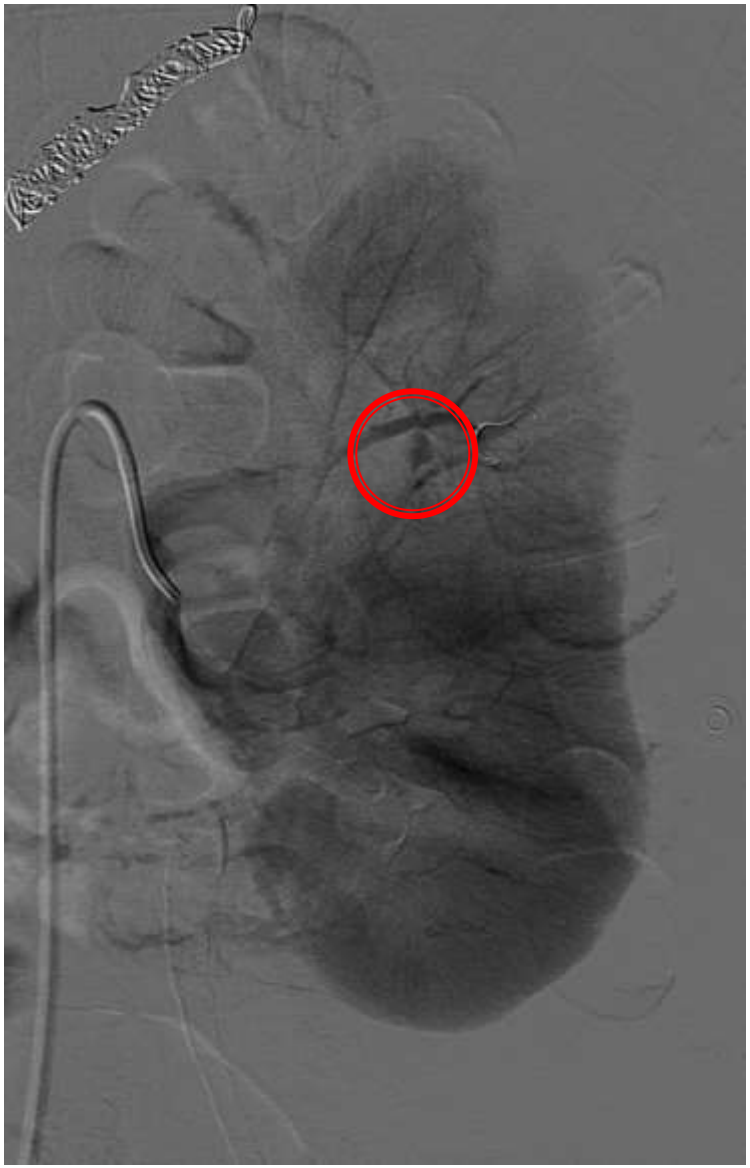
F/63 Motor Vehicle Accident



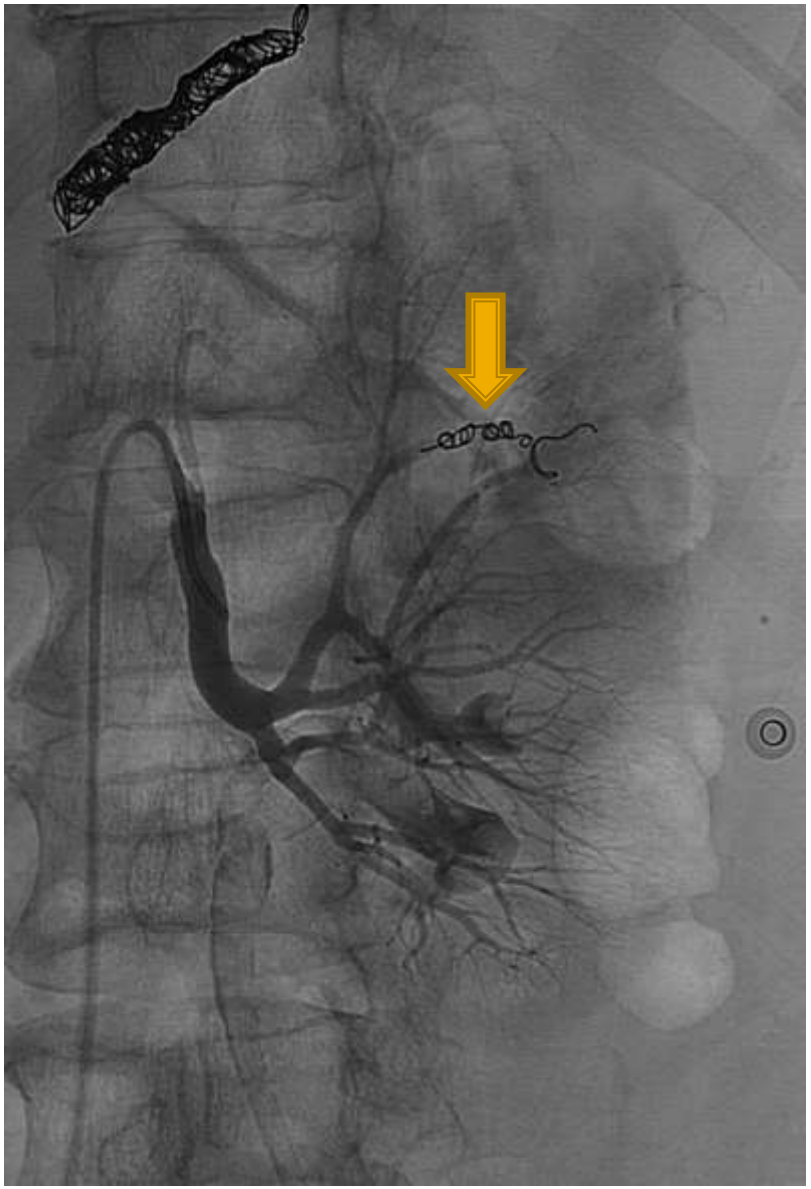


Arteriovenous fistula

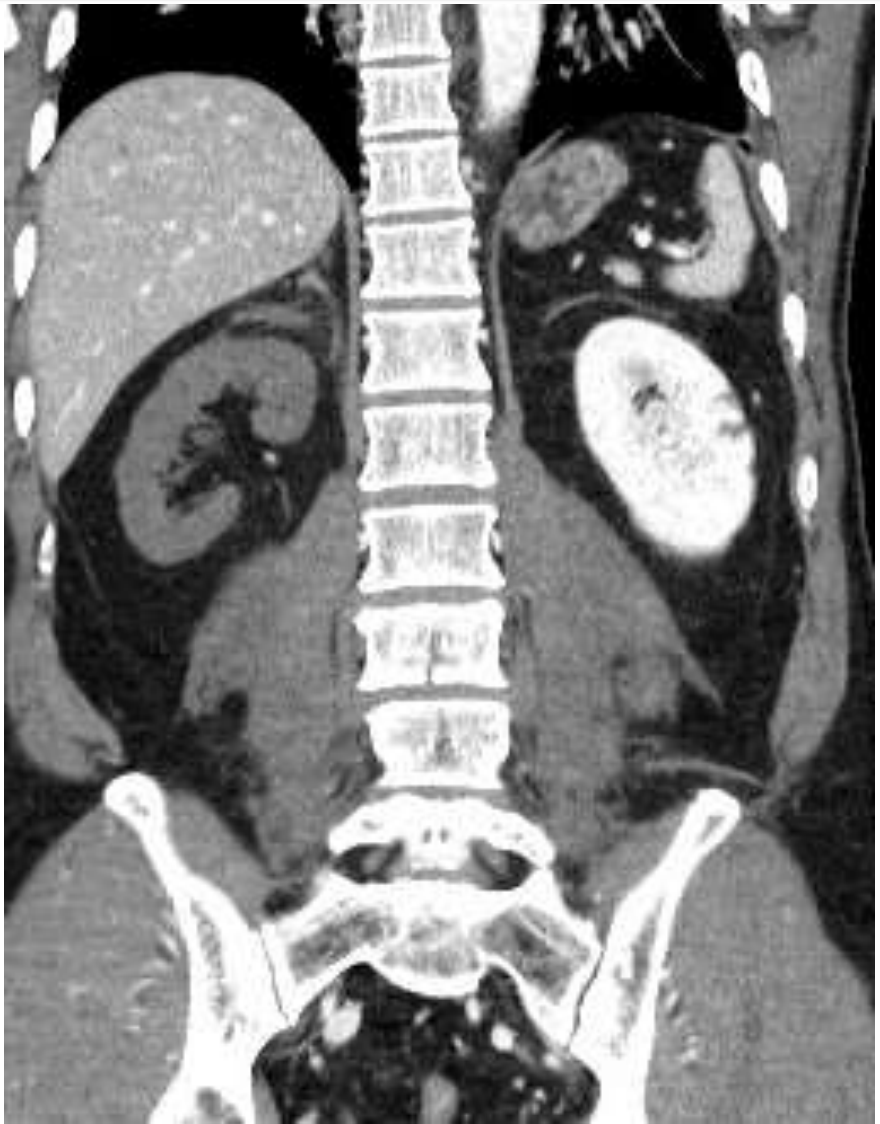




Pseudoaneurysm



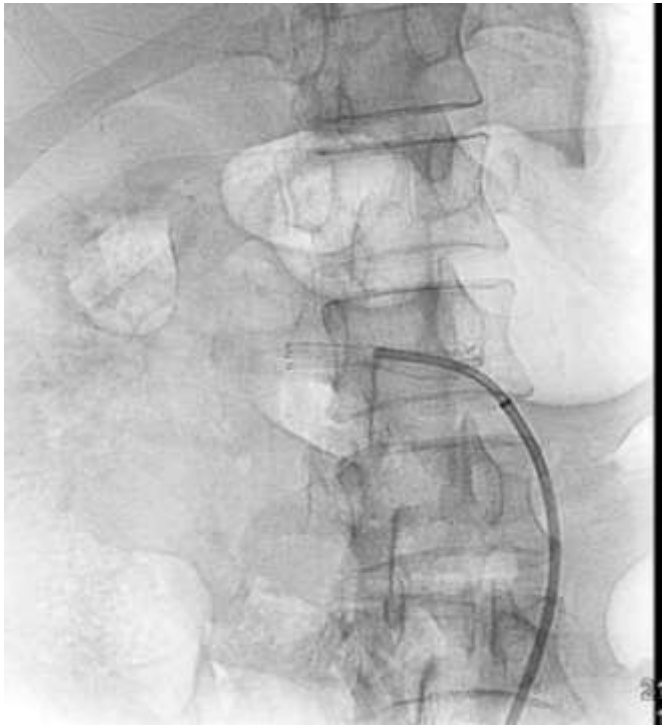
M/52, 5m fall down injury

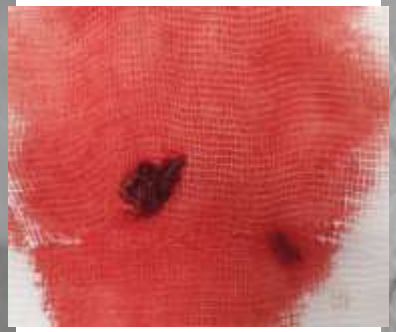


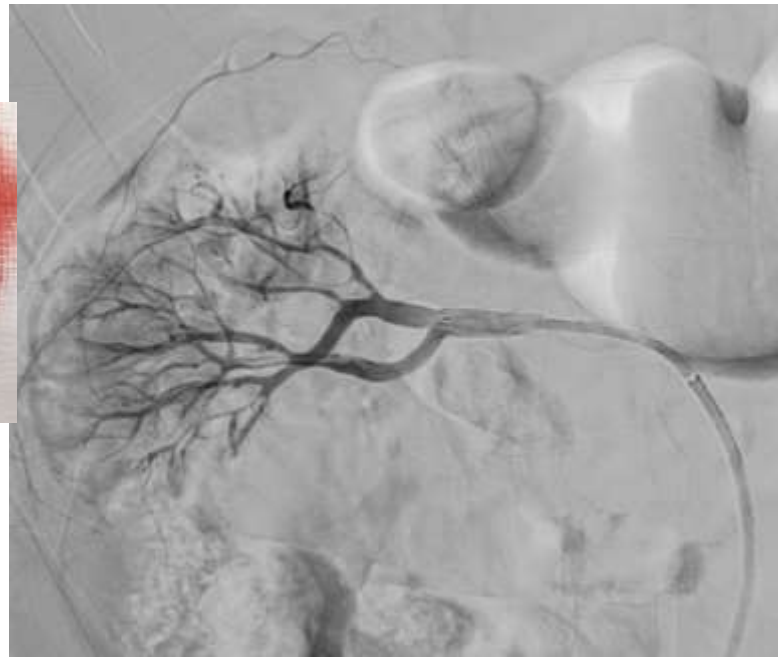
Traumatic dissection

Golden time of Kidney

- Ischemia for 4 hours is reported to cause irreversible renal damage
- Complete main renal artery occlusion lasting more than 6 hours, or a partial main renal artery occlusion of more than 24 hours duration
- It was shared a golden time of 24 hours to be considered as a watershed to interventional renal procedures in renal ischemia







2 months F/U CT

Pelvic Trauma

World J Surg (2008) 32:1874–1882
DOI 10.1007/s00268-008-9591-z

World Journal of Surgery

Acute Management of Hemodynamically Unstable Pelvic Trauma Patients: Time for a Change? Multicenter Review of Recent Practice

Diederik Verbeek · Michael Sugrue · Zsolt Balogh · Danny Cass · Ian Civil · Ian Harris · Thomas Kossmann · Steve Leibman · Valerie Malka · Anthony Pohl · Sudhakar Rao · Martin Richardson · Michael Schuetz · Caesar Ursic · Vanessa Wills

Table 2 Primary cause of death ($n = 69$)

Diffuse hemorrhage	22 (31.9%)
Pelvic hemorrhage	20 (29.0%)
Traumatic brain injury	15 (21.7%)
Respiratory	5 (7.2%)
Multiple organ dysfunction syndrome	3 (4.3%)
Sepsis	2 (2.9%)
Cardiac arrest	2 (2.9%)

- 11,109 major blunt trauma (mortality 14.7%)
  - 1,050(10%) major pelvic fracture (mortality 17.0%)
    - 217(20%) hemodynamically unstable
      - 69(30%) death
        - 52(75%) within 24 hours
          - 42(80%) hemorrhage is primary cause of death

Principle of treatment

- **Decrease pelvic volume**
  - External stabilization (sheet wrapping, C-clamp, external fixator)
  - Sponge packing (tamponade) 단점:
    - Risk of infection and compartment syndrome
    - Can only control venous and smaller arterial bleeding
- **Treat bleeding focus**
  - Surgical exploration and ligation 단점:
    - Difficult to control bleeding (localization, extensive collateral network…)
    - Can relieve compartment syndrome
    - Reduces tamponade effect → may increase bleeding risk
  - Embolization

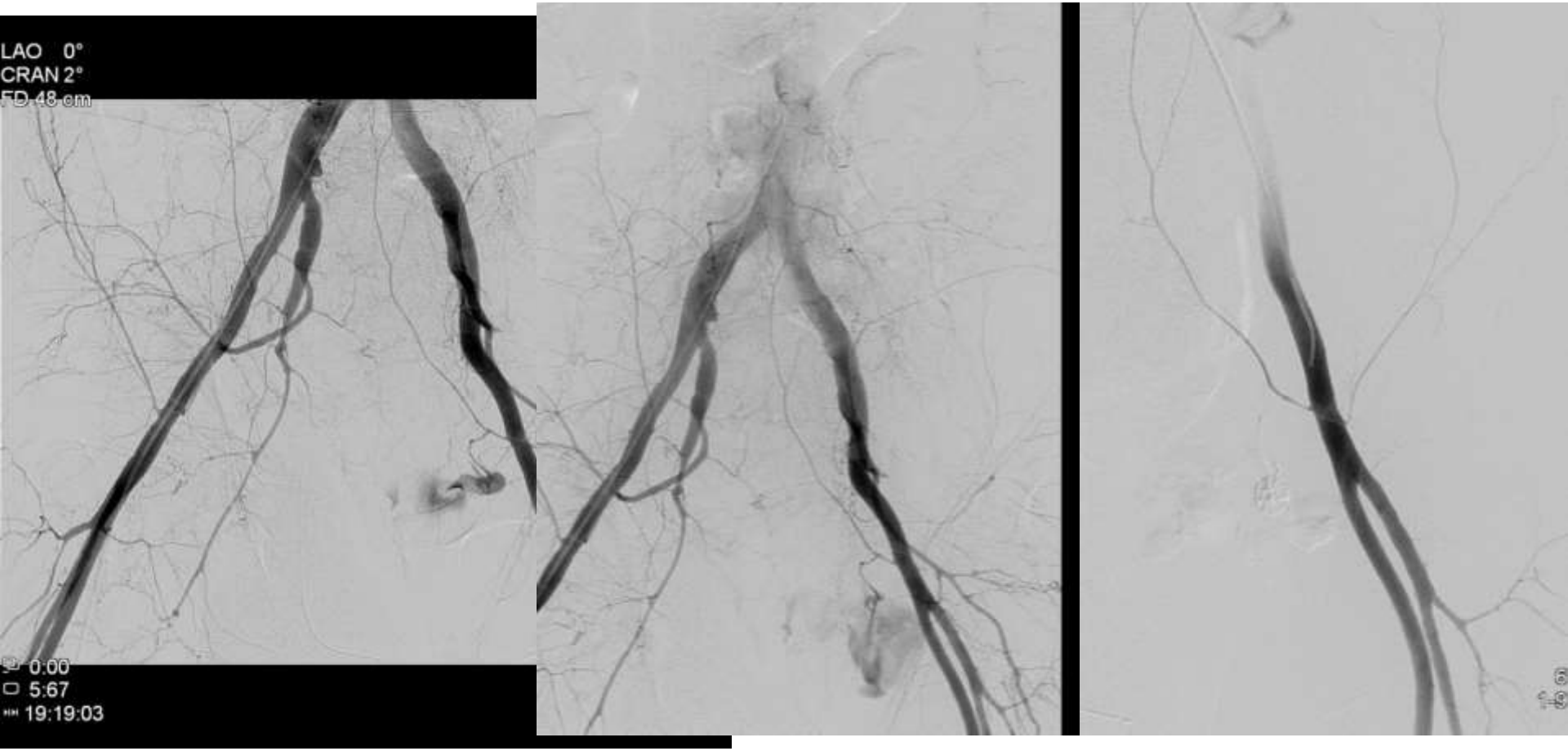
Embolization

- Persistent hypotension시 문헌에 따라 57~75%까지 active arterial bleeding이 있다고 보고
- Hemodynamically unstable 환자에서 일차적인 pelvic stabilization, packing 등 응급조치 후 필요시 embolization 시행
- Hemodynamically stable 환자에서 CT상 arterial bleeding이 발견되면 primary modality로 embolization 시행
- 문헌에 따라 임상적 성공율이 85 – 100% 정도로 보고됨

M/51
유압기에 깔림

esy of Ji ae Kim


Spin: 0
Tilt: 0
A

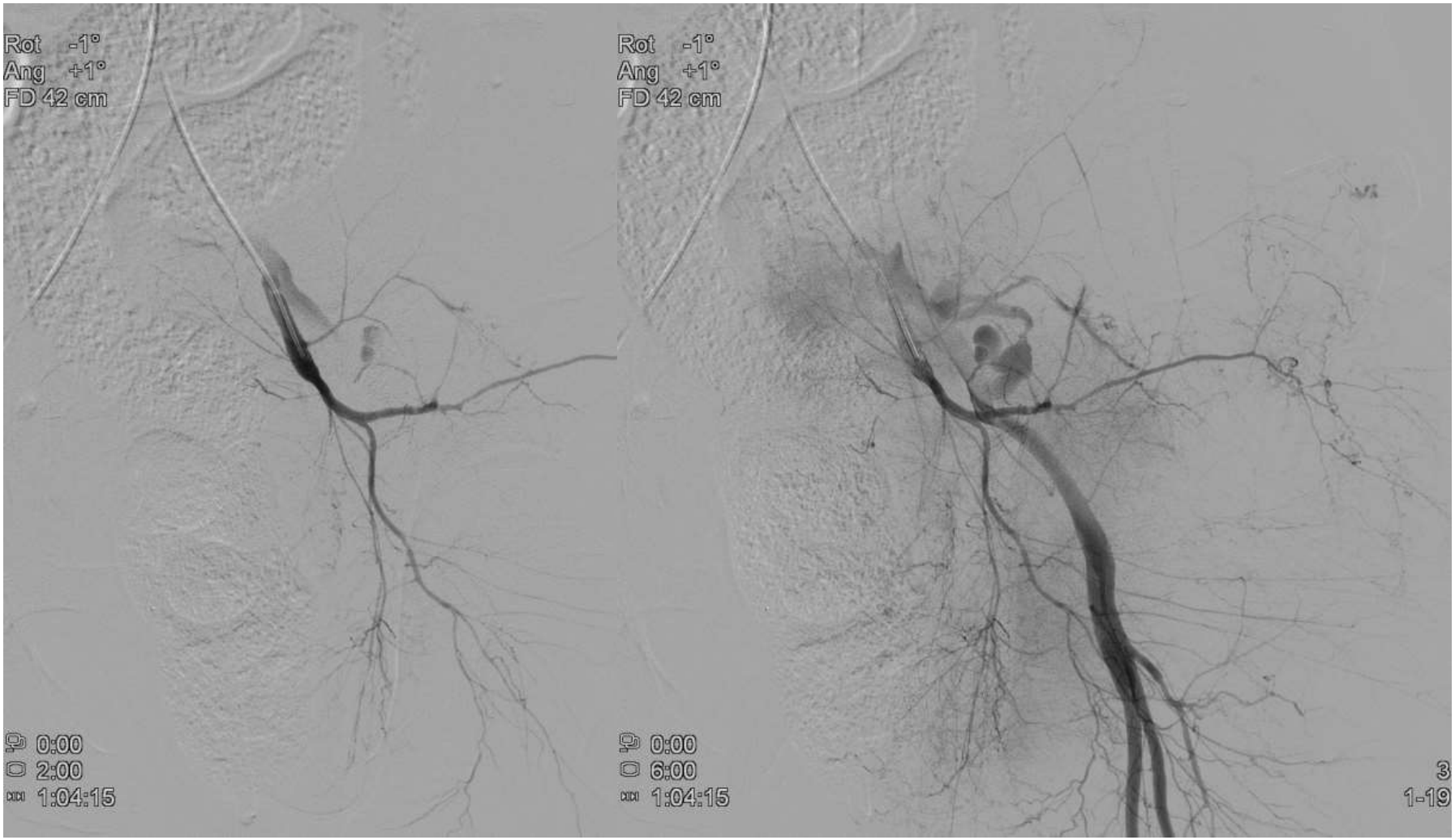


Cremasteric artery embolization using glue

M/61

Hit by falling H-beam

Courtesy of Ji Dae Kim


Rot -1°
Ang +1°
FD 42 cm
0:00
2:00
1:04:15
Rot -1°
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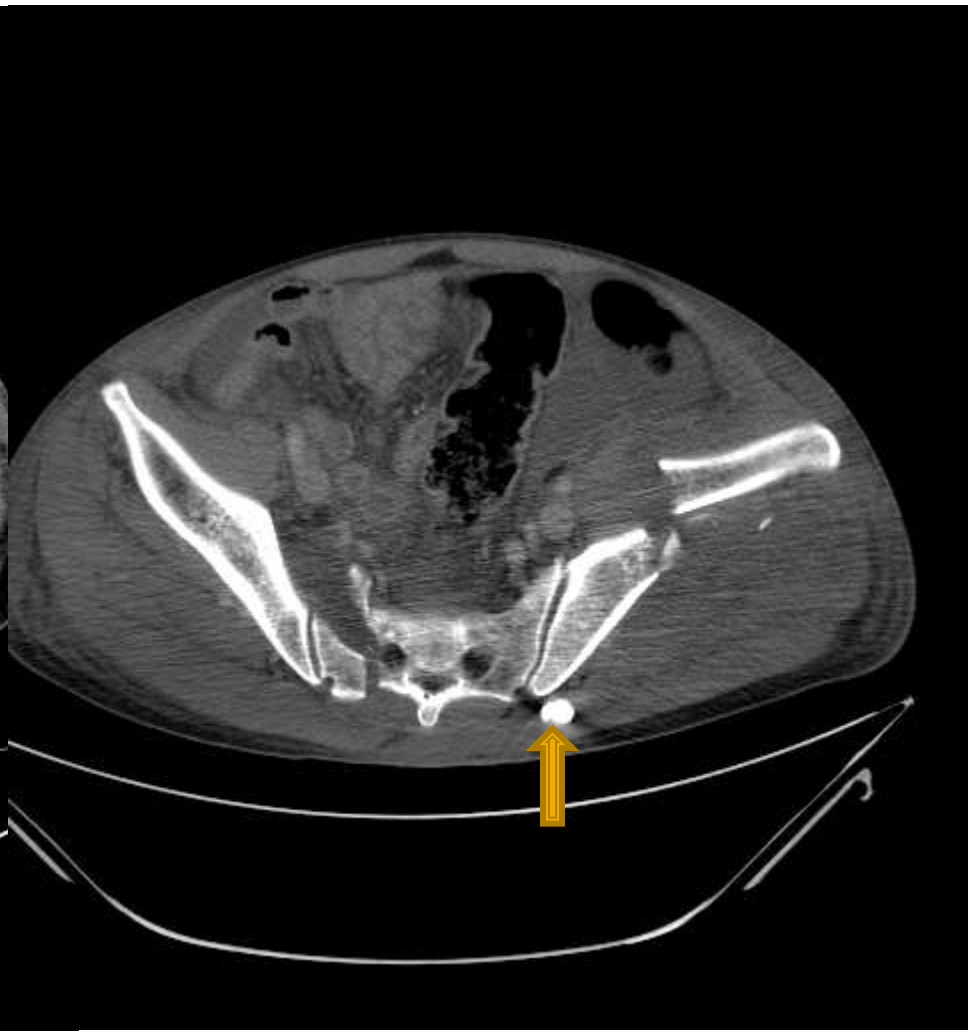
6:00
1:04:15
3
1-19

Embolization of superior gluteal artery using glue and gelfoam



Embolization in blunt trauma

- **Supportive role** in conservative management and surgery
- **Expanding indications:**
  - Hemodynamically stable vs unstable patients
  - Bridge to surgery vs Definitive treatment
  - Rebleeding after surgery
  - Polytrauma setting
- **Increasing role** in trauma setting due to advancements in co-axial devices and technique

Reality issues for IR

- IR standby:
  - Better outcomes in institutions with 24 hours/day, 365 days/year on-call support from IR
- The faster the intervention, the better the prognosis
  - Embolization < 3 hours --> increased survival (Agolini et al. 1997)
  - Embolization < 1.5 hours --> decreased mortality (Balogh et al. 2005)

Etiology of Blunt Traumatic Thoracic Aortic Injury

- Overall incidence : < 0.5%
  - Traffic accidents : 0.3%
  - High-level falls : 0.1%
- Mechanism
  - Motor vehicle crash (70%)
  - Motorcycle crash (13%)
  - Fall from heights (7%)
  - Auto vs pedestrian (7%)

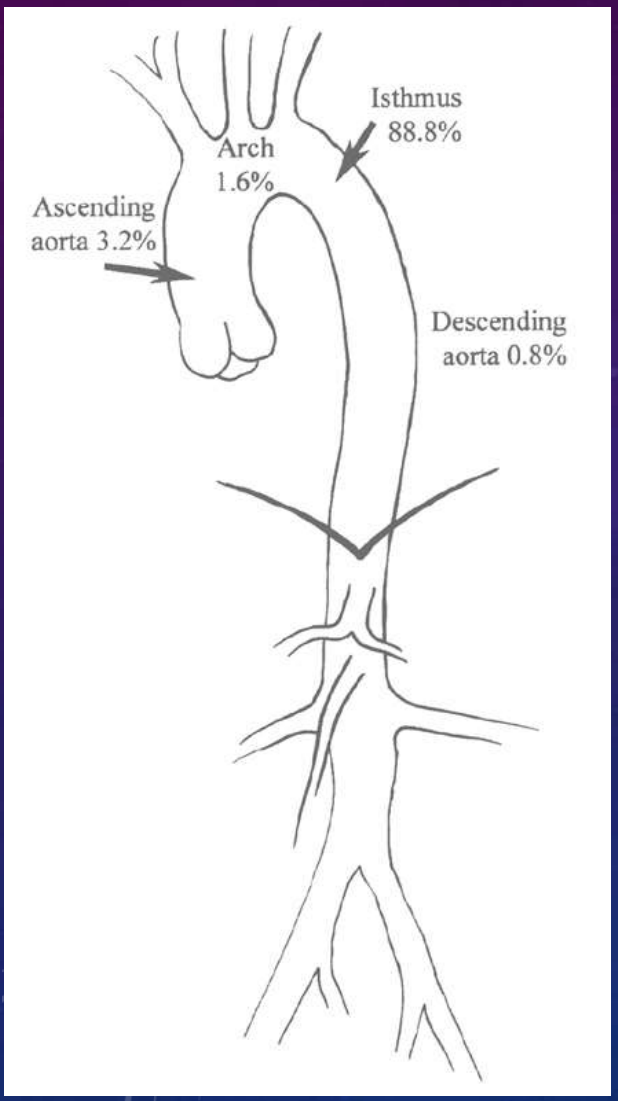
- BTAI incidence : age ↑ / pediatric population ↓
  - <16 yrs -> 7 times lower than in adults

NATURAL HISTORY

- Prehospital mortality : 70-80%
- Patients arriving to the hospital alive, 50% died within 24 hrs
  - Scene (57%)
  - < 4 hrs of admission (37%)
  - >4 hrs of admission (6%)

Emerg Med J 2004;21:414–419

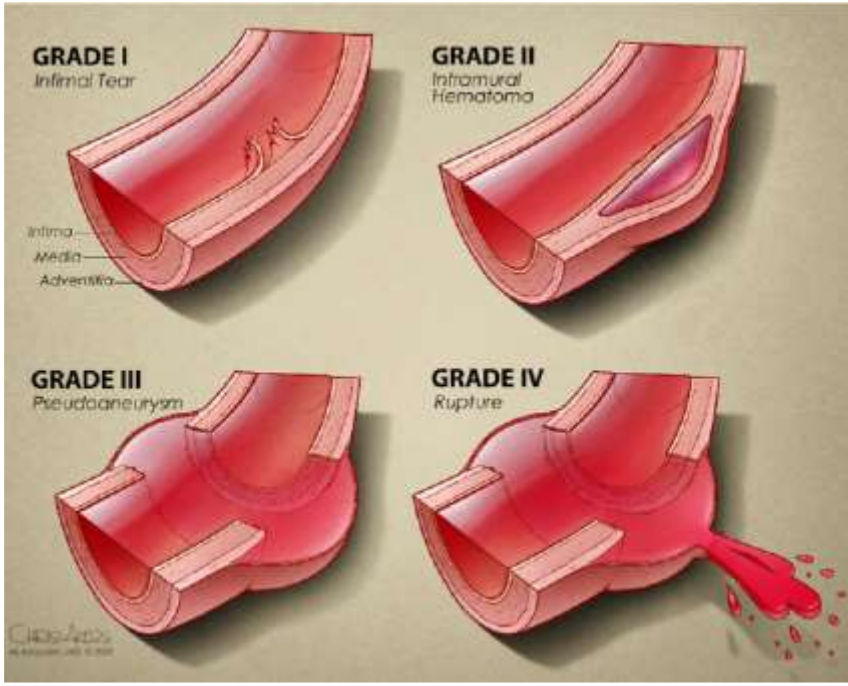
DISTRIBUTION OF AORTIC INJURIES



- In computer simulation and cadaver studies, showed that at the time of the crash the intra-aortic pressure increases to a mean of 1,449 mmHg.
- This high pressure combined with rotational forces, exerts a highly focused stress at the isthmus.
- In addition, the tensile strength at the isthmus was found to be only 63% of that of the proximal aorta.

Classifications of traumatic aortic injury

- Grade I
  - Intimal tear or flap
- Grade II
  - Intramural hematoma w/o external contour change
- Grade III
  - Pseudoaneurysm
    - with external contour change
    - w/o extravasation of contrast
- Grade IV
  - Full-thickness tear with extravasation of contrast



J Vasc Surg 49(6): 1403-1408

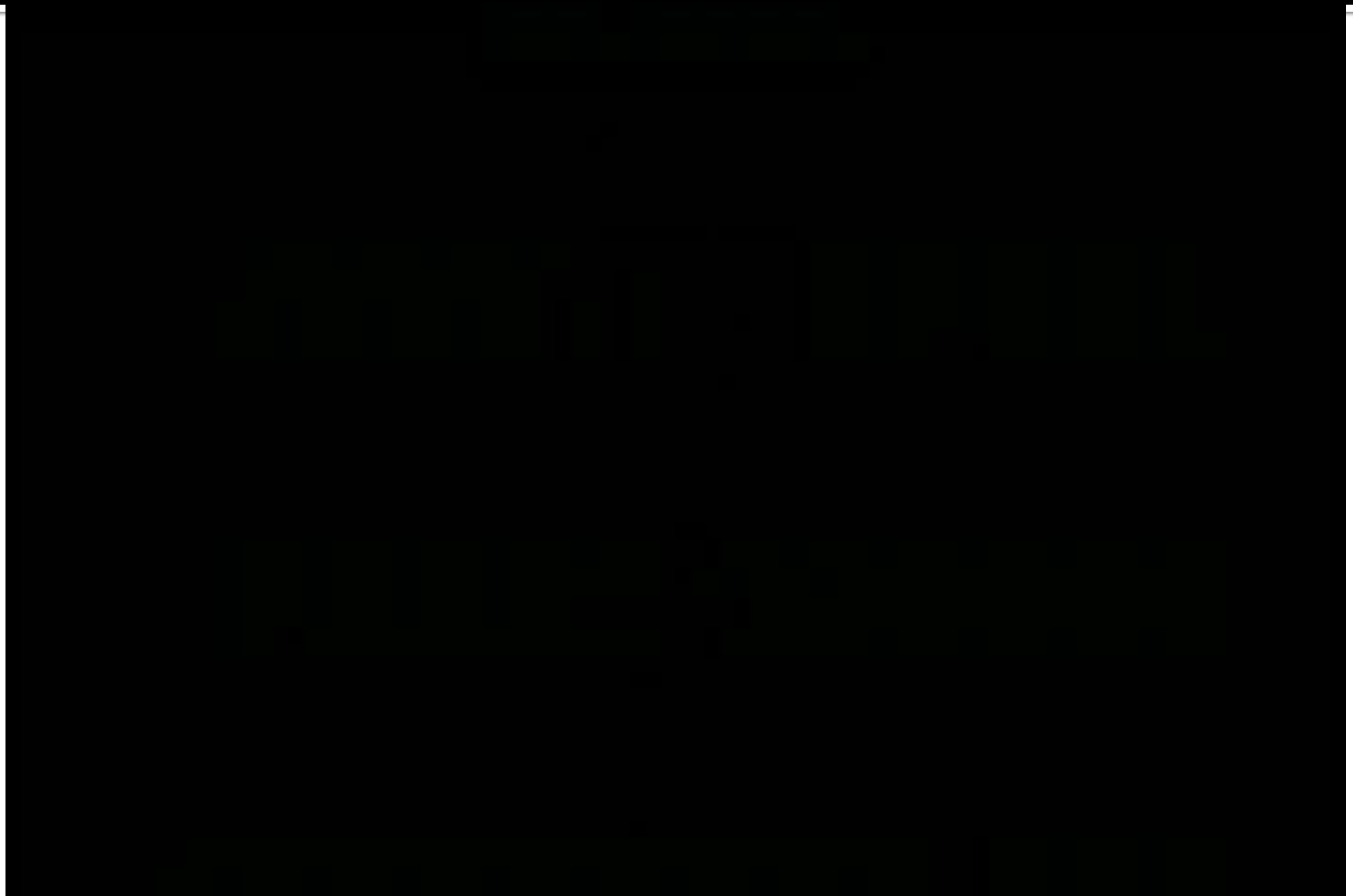
INDICATION

- **2011 SOCIETY FOR VASCULAR SURGERY® DOCUMENTS**

- GR I -> not repaired
- GR II – IV -> should be repaired

- **Non-operative management of TBAI…**

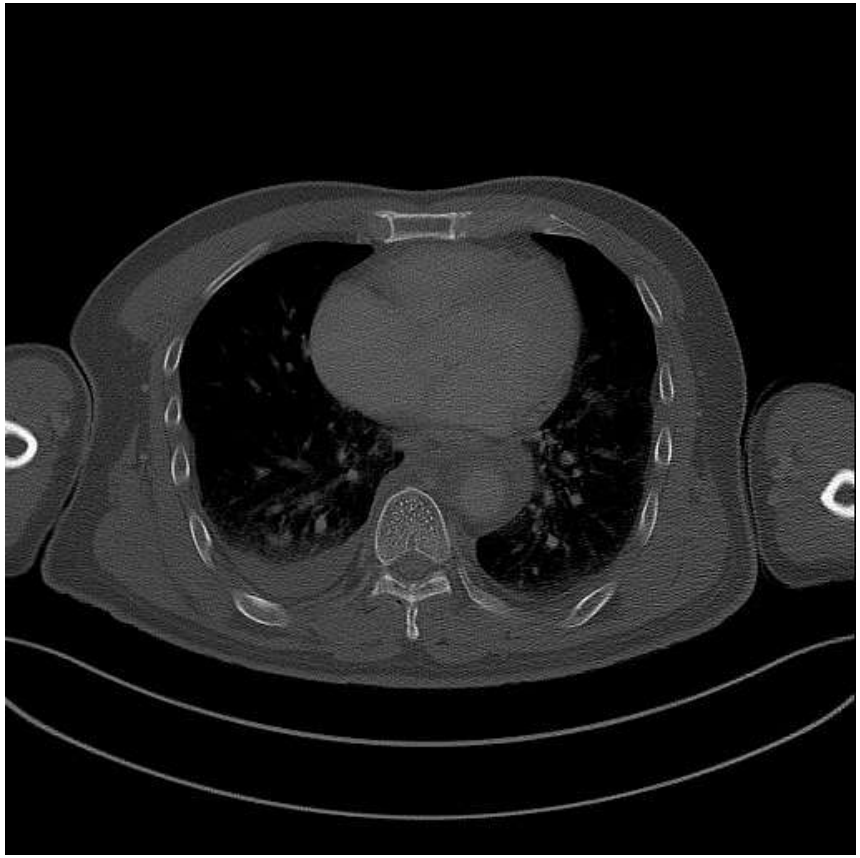
Thoracic endovascular aortic repair (TEVAR)

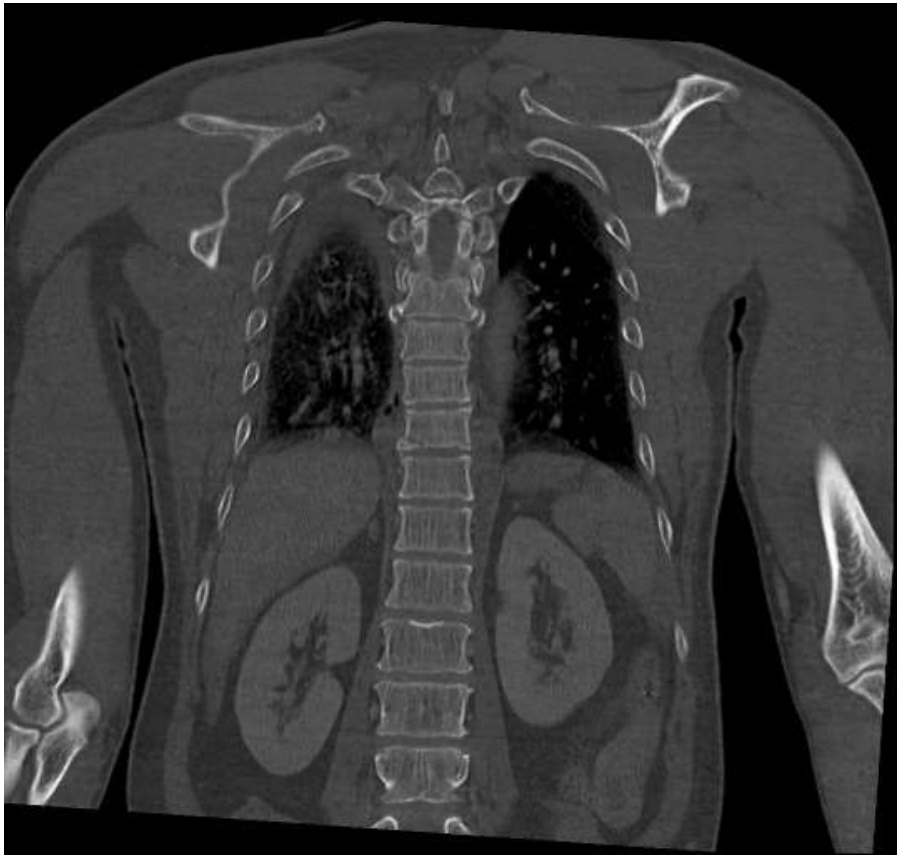


CASE PRESENTATION

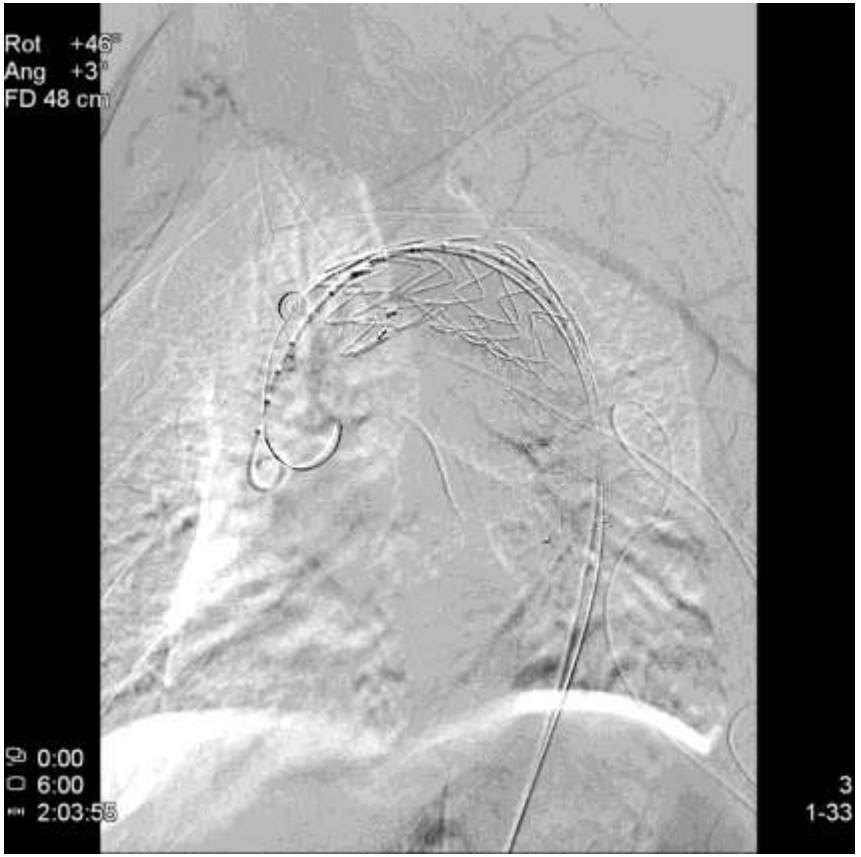
- M/45
- Autovehicle TA
- Multiple trauma
  - Traumatic SDH
  - Intraperitoneal organs
  - Pelvic bone Fx

2018-7-6 Aorta CT(outside institution)

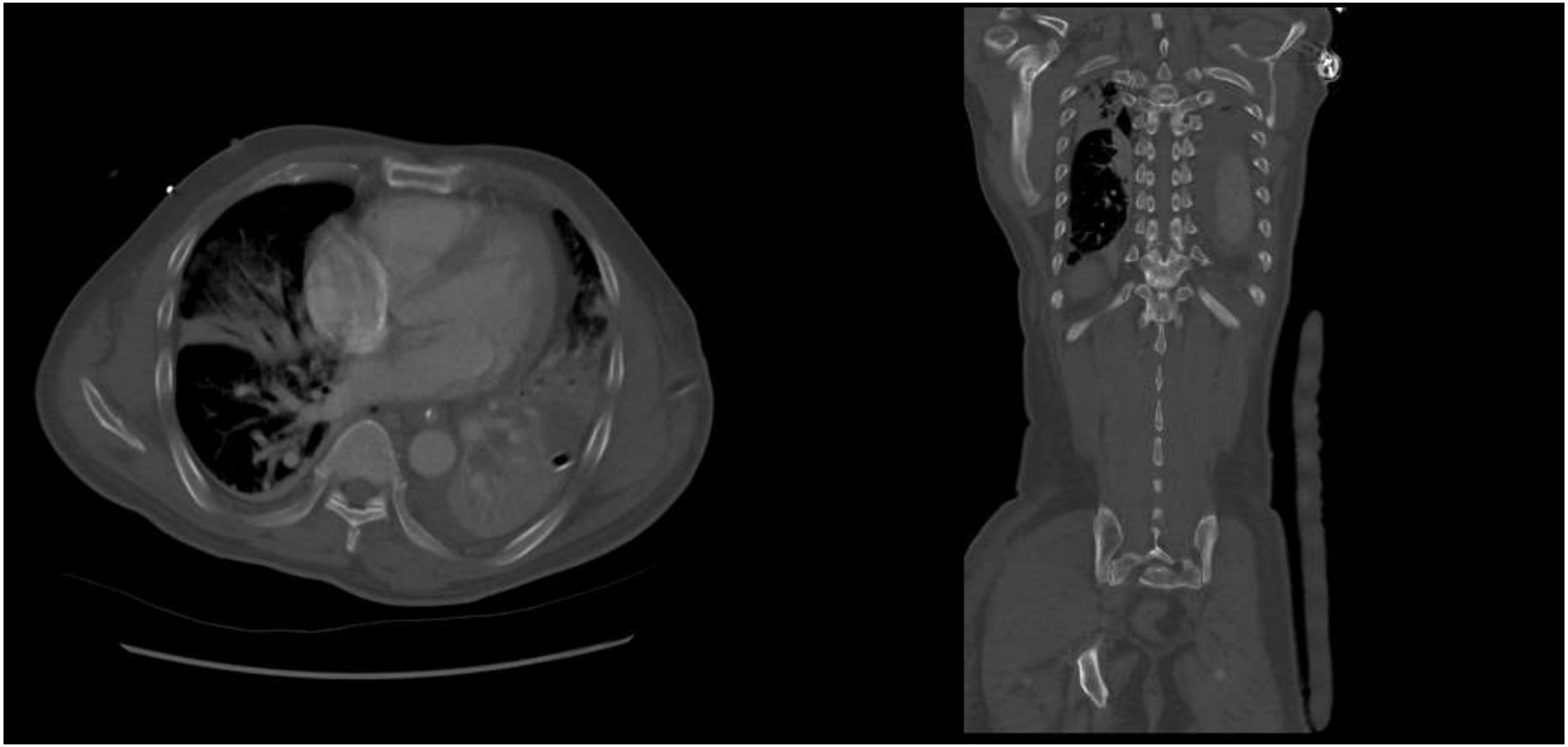




2018-7-7 TEVAR



2018-7-16 Aorta CT



AJOU TRAUMA CENTER EXPERIENCE

AJOU TRAUMA CENTER EXPERIENCE

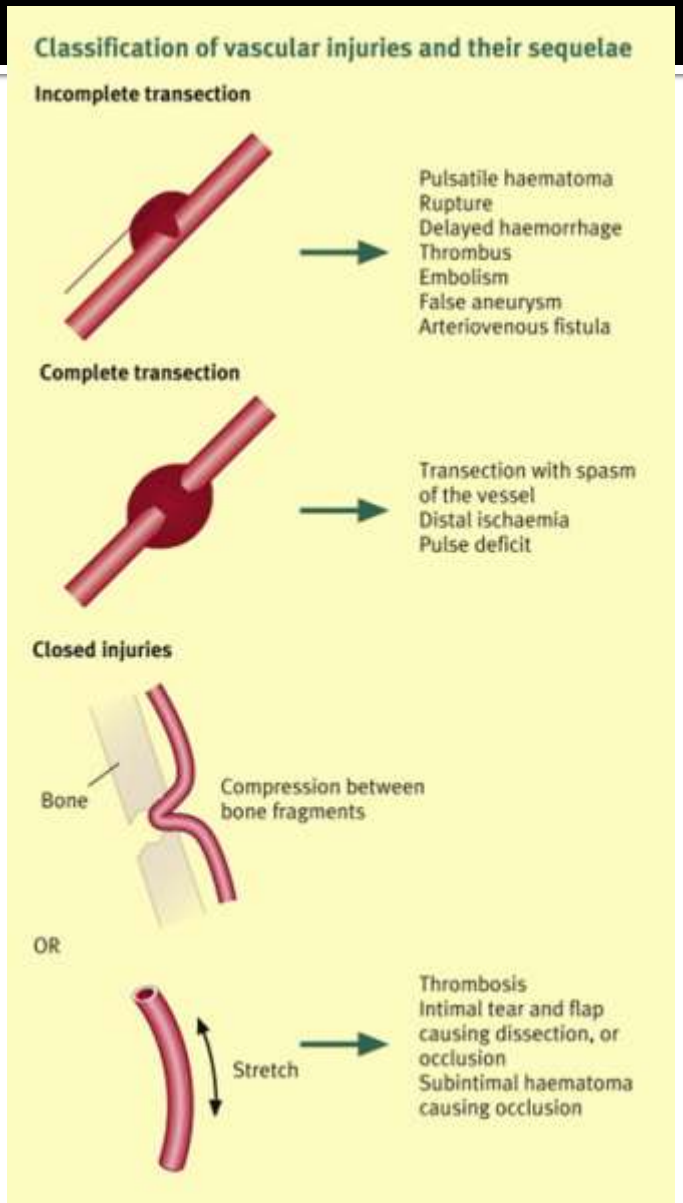
Grade	Gr I	Gr II	Gr III	Gr IV	
Mortaliy	0/5 (0%)	3/9 (33%)	3/12 (25%)	3/8 (37%)	9/34 (26%)
Mortality a/w TABI	0/5 (0%)	2/9 (22%)	0/12 (0%)	2/8 (28%)	4/34 (13%)

AJOU TRAUMA CENTER EXPERIENCE

Management	NOM	TEVAR	OR	
Mortaliy	7/18 (39%)	1/14 (7%)	1/2 (50%)	9/34 (26%)
Mortality a/w TABI	3/18 (21%)	0/14 (0%)	1/2 (50%)	4/34 (13%)
Complication		Endoleak 2 LCA stent 1		

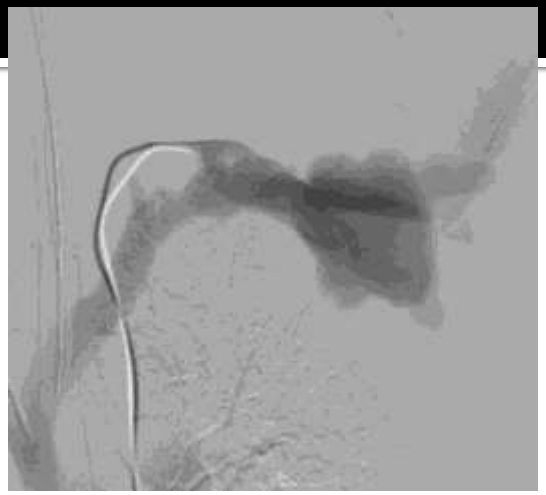
Traumatic Peripheral vascular Injury

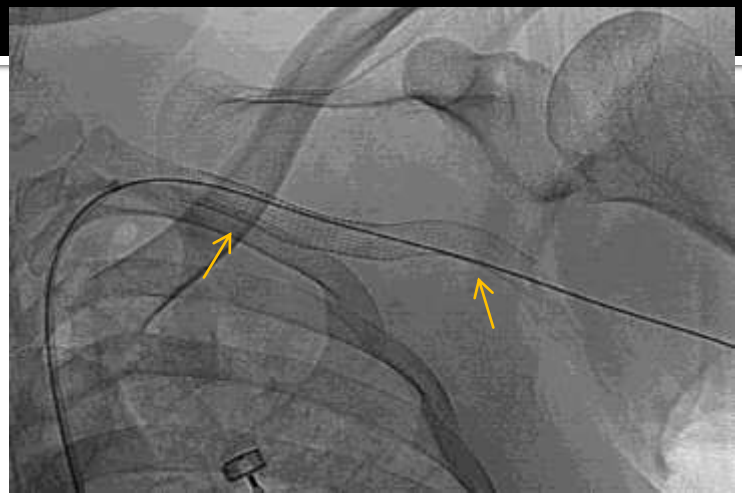
- Type of vascular injury
  - Dissection
  - Thrombotic occlusion
  - Rupture
  - Transection



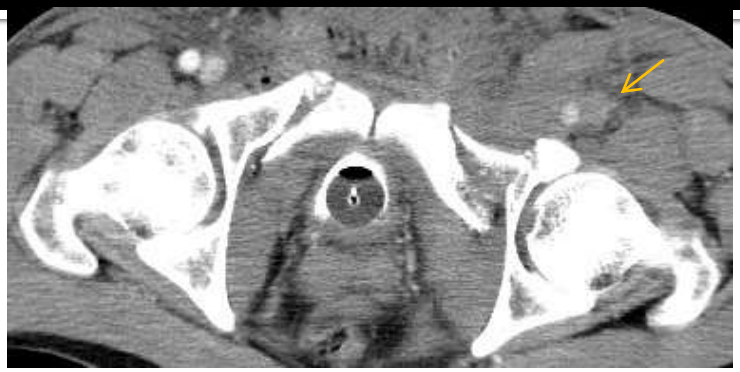
Surgery (Oxford). Volume 27, Issue 8, August 2009, Pages 331-336

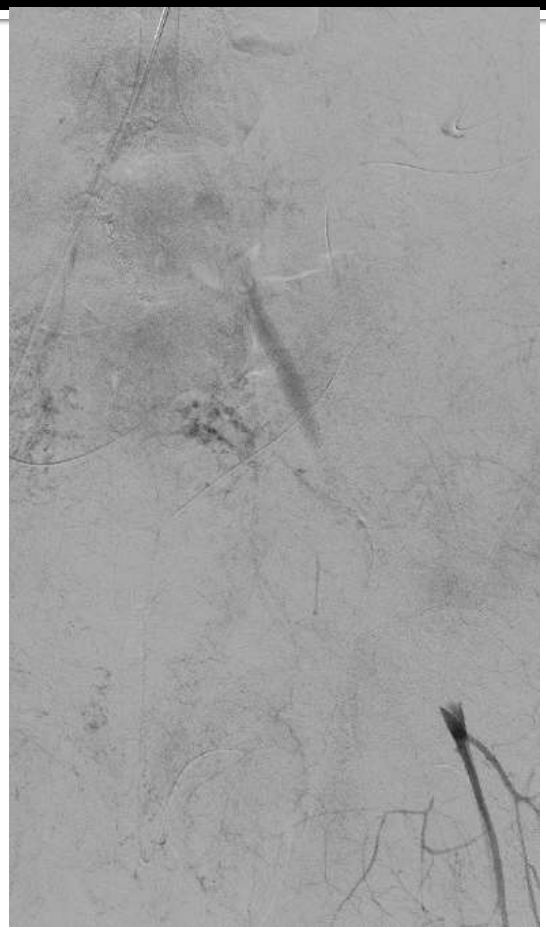
Results : Case 1.



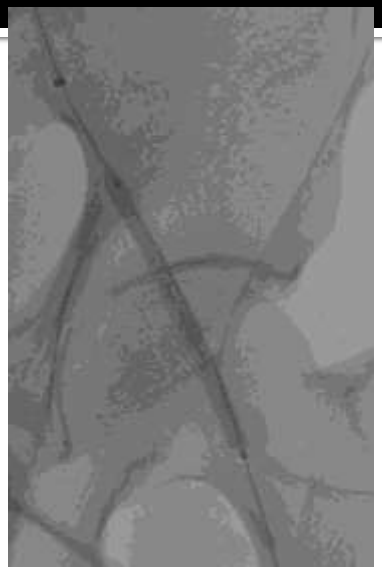


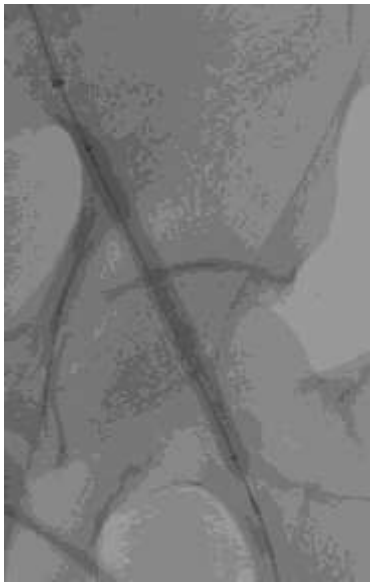
Results : Case 2.

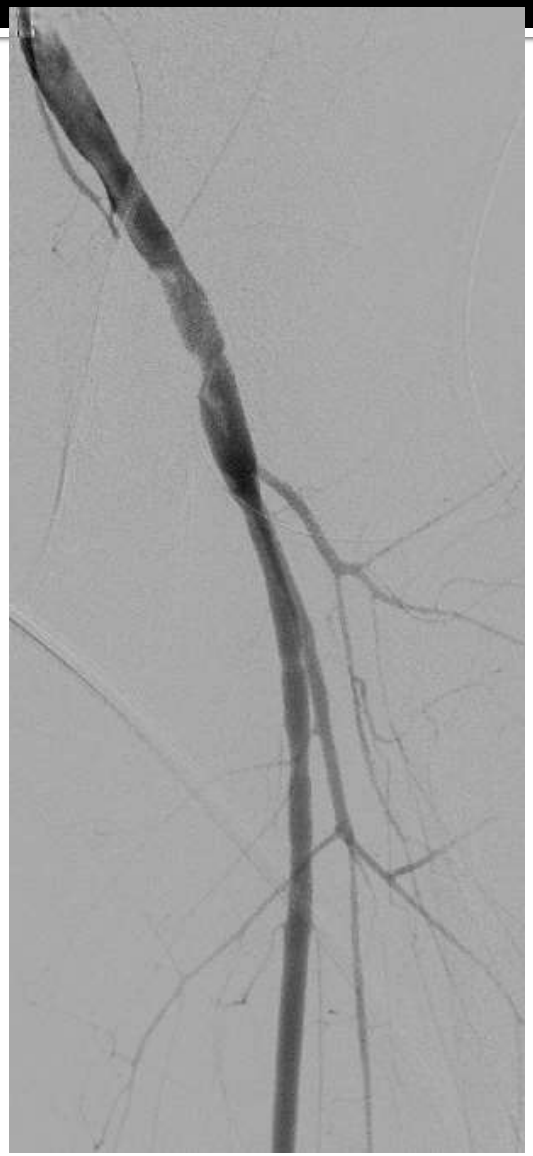




Results : Case 2.



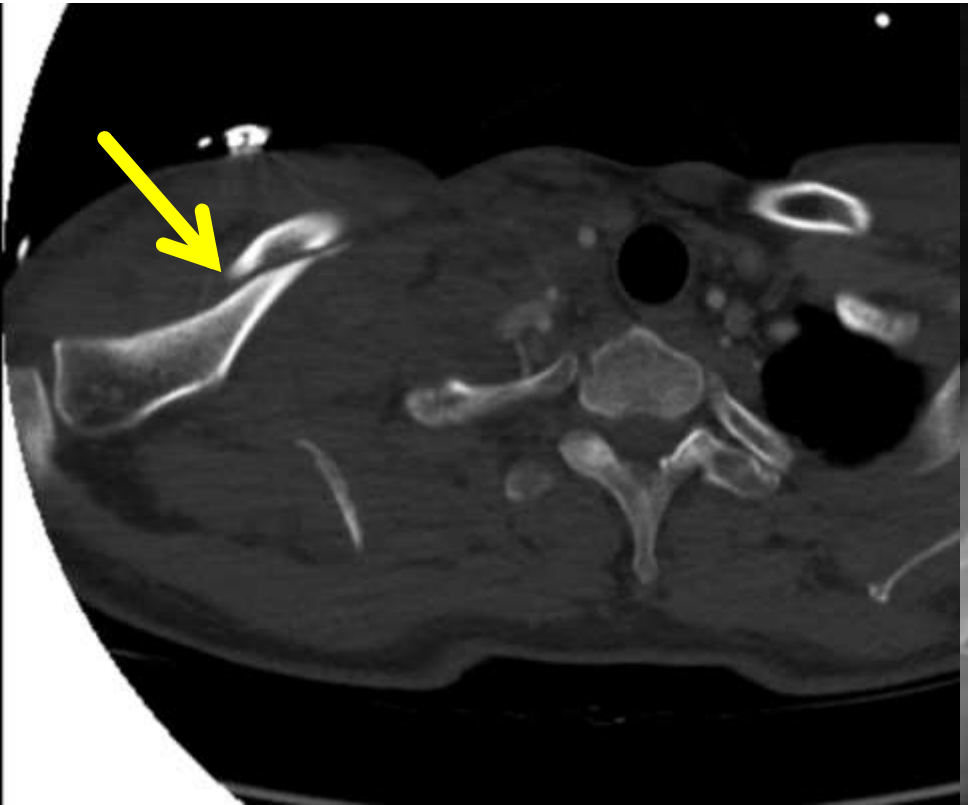


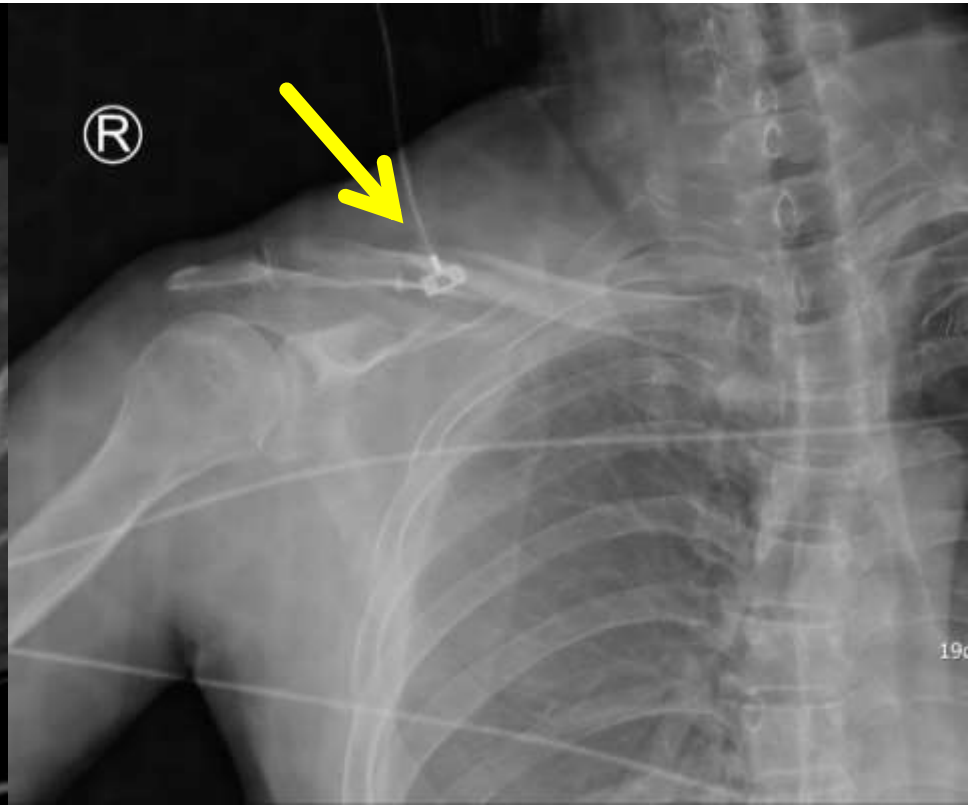


F/U after 8 days

M/48

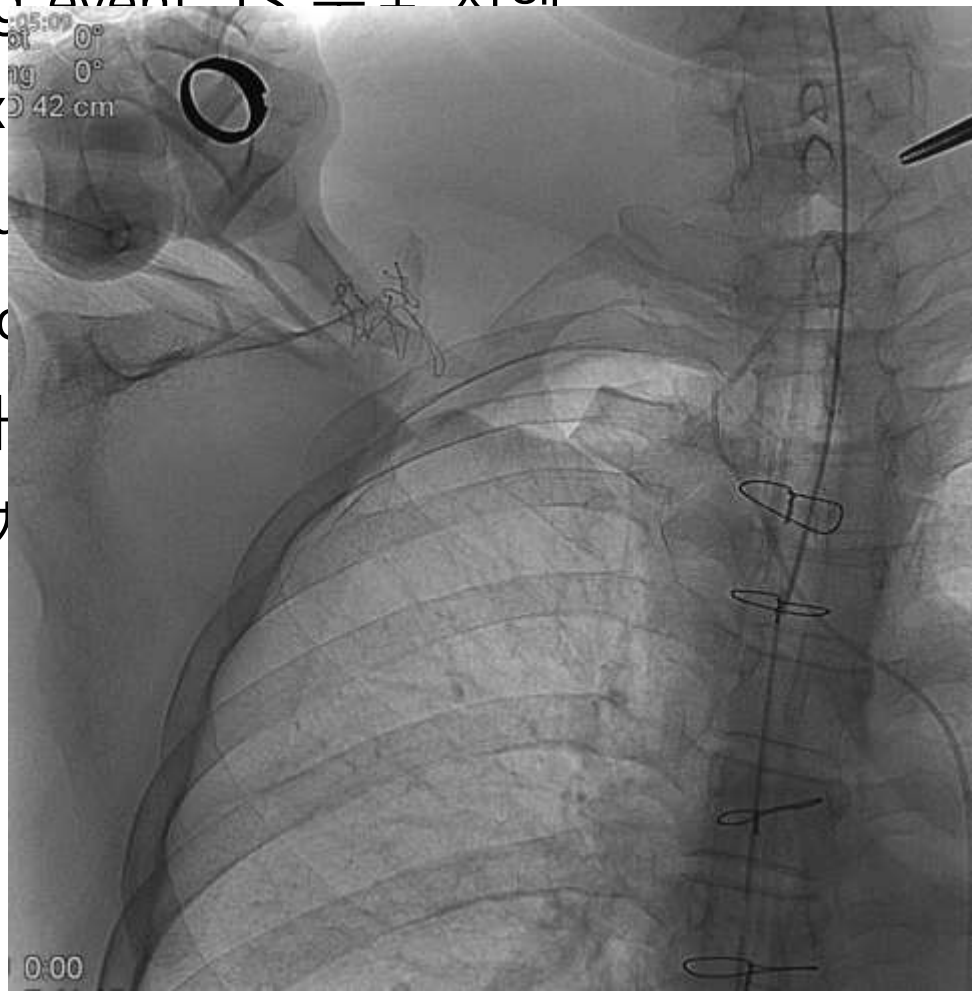
- C/C: 자전거로 비탈길 내려가다가 넘어짐.



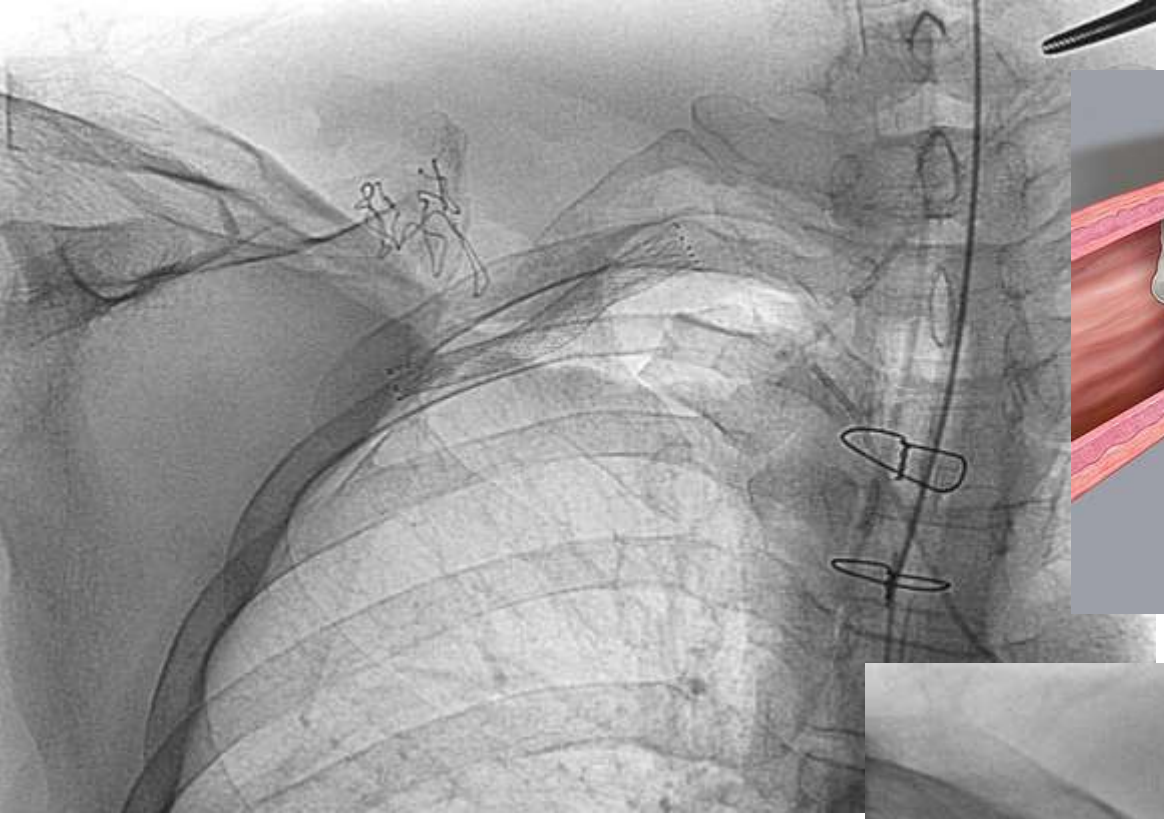


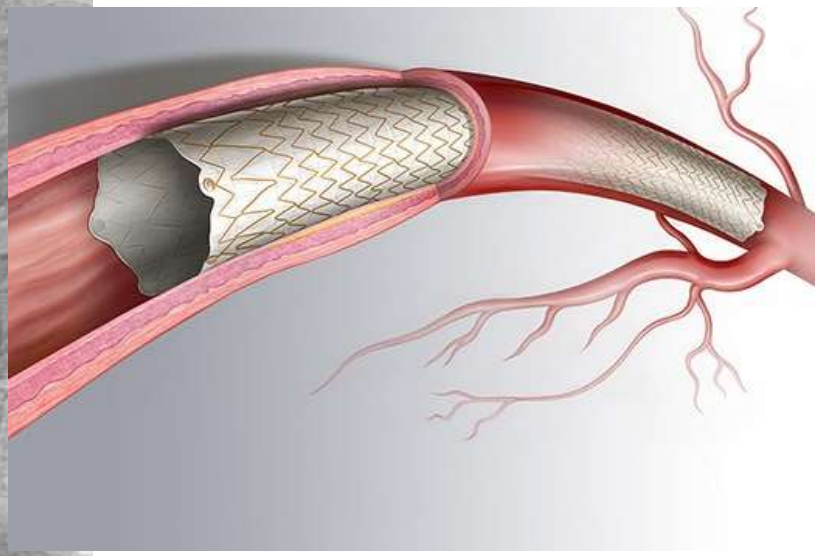
D13, ORIF for Rt clavicular fracture

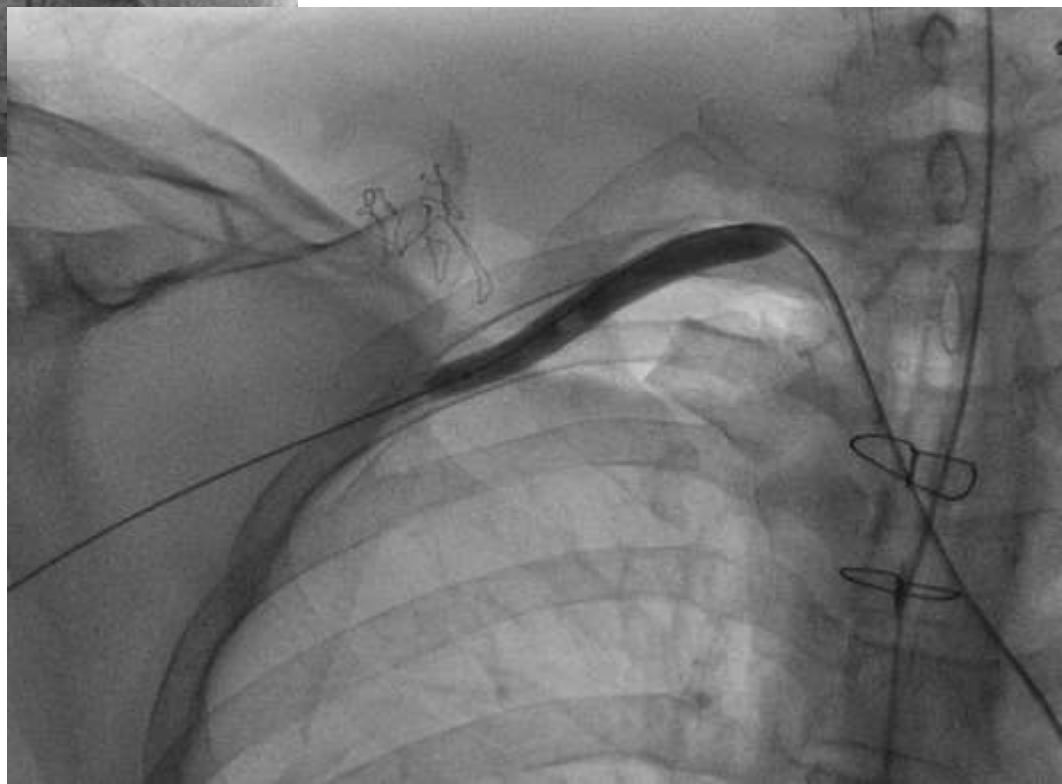
- OS 수술 중 massive bleeding event, TS 수술 시행
- Rupture 부위가 clavicle prox
  부위여서 rupture site exposu
  후 Rt subclavian artery의 pr
- Bleeding이 너무 많아 시야가
- Finger compression 유지한 채

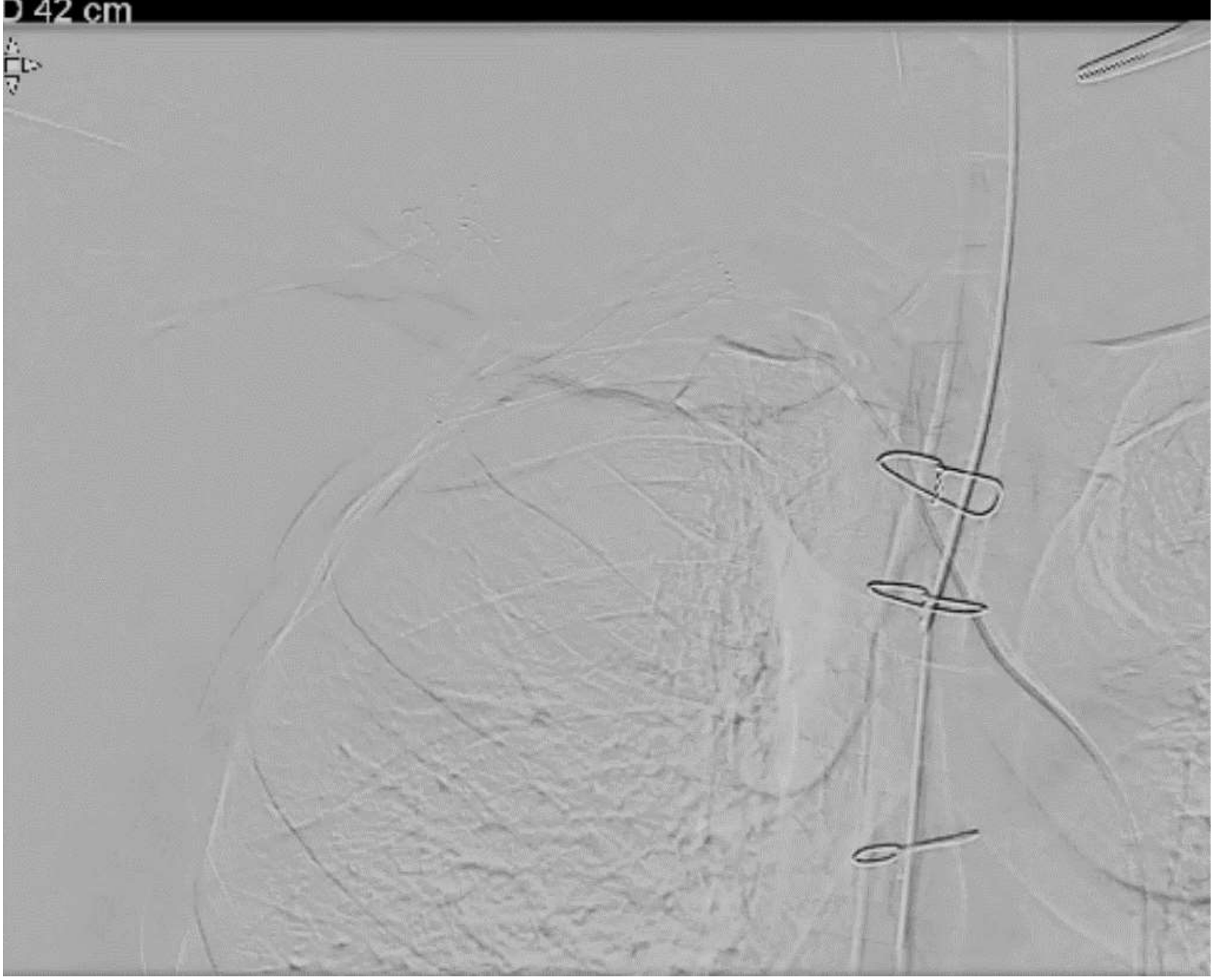


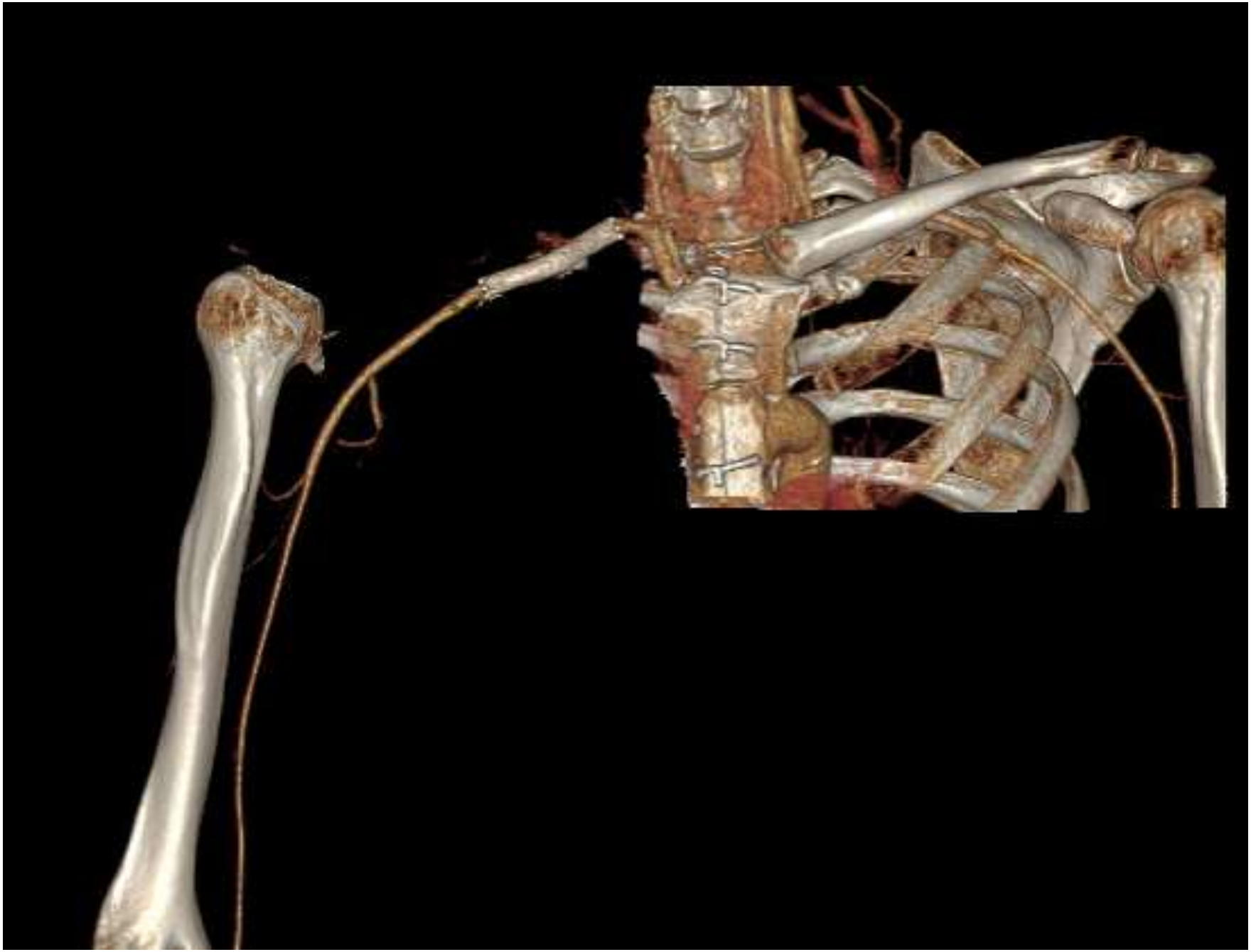

ot 0°
ng 0°
D 42 cm
0:00
0:50
7:41:15
32-








D 42 cm



Summary

- Embolization is now an everyday practice in trauma centers. **Expanding indications**
- Thoracic stent-graft can be performed for Blunt Traumatic Thoracic Aortic Injury
- Endovascular treatment is useful for revascularization and exclusion of bleeding in the emergent setting
- IR should be integrated into multidisciplinary trauma teams to establish guidelines and protocols