Basic Hemodialysis – Vascular Access

Vascular Access Placement and Outcomes in the Medically Challenged Patients

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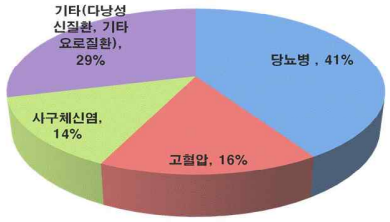
Causes of ESRD



Comparisons of patency *vs* non-patency fistulas with regard to some variables

	Patency		Non-patency			
	n	%	n	%	χ^2	*p*
Sex					0.000	1.000
Female	84	82.4	18	17.6		
Male	255	82.3	55	17.7		
Heparin used per hemodialysis						0.137
+	325	81.7	73	18.3		
–	13	100.0	–	0.0		
Smoke history					1.492	0.222
Nonsmoker	92	78.6	25	21.4		
Smoker	247	83.7	48	16.3		
Diabetes mellitus					4.266	**0.039**
Patient	46	93.9	3	6.1		
Non-patient	293	80.7	70	19.3		
Hemodialysis count					17.326	**<0.005**
< 3	94	96.9	3	3.1		
≥ 3	245	77.8	70	22.2		
Previous dialysis catheter insertion						**0.012**
–	68	93.2	5	6.8		
+	271	79.9	68	20.1		
Malignant neoplasm						**0.008**
Patient	28	100.0	–	0.0		
Non-patient	311	81.0	73	19.0		

Renal Failure, 28:275–281, 2006

Age

- **Wrist radiocephalic AVF** in elderly patients (50~70 years)
  - High primary failure rate
  - Low patency rate
  - → Increased incidence of comorbidities(peripheral vascular ds., DM etc)

Sex

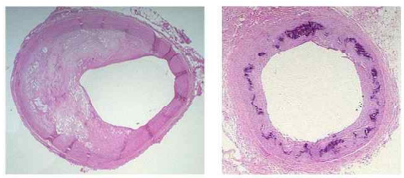
- **Female sex**
  - Graft >> AVF
  - Little evidence for AVF patency differences
  - Caplin et al; same arterial and venous diameter
  - → similar maturation and 1-year patency rate

Diabetes

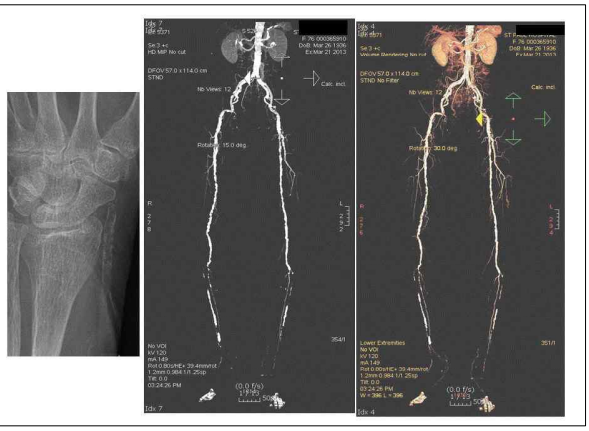
- Increased use of graft
  - Arterial calcification
  - Diameter & arterial peak systolic volume: not different
    → similar outcome
  - Increased proximal fistula
    →similar access survival
  - Steal syndrome increased
  - Careful preoperative vessel imaging & AVF site selection

Arterial disease in Diabetes

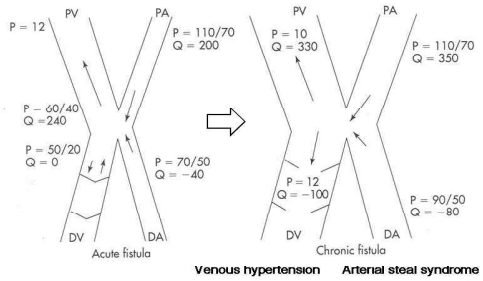
1. Atherosclerosis
   - arterial narrowing & occlusion → ischemia
2. Medial sclerosis
   - calcification of the tunica media → rigid artery without encroachment on the arterial lumen → interfere with indirect measurement of arterial blood pressure



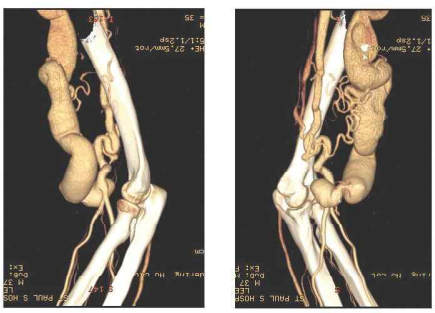
Atherosclerosis Medial sclerosis



Pressure and flow in idealized side-to-side acute and chronic AV fistula



Pressure and flow in chronic AV fistula



Characteristics of Diabetic Vasculopathy

"There are no peripheral arterial lesion specific to diabetes but the pattern of atherosclerosis is different."

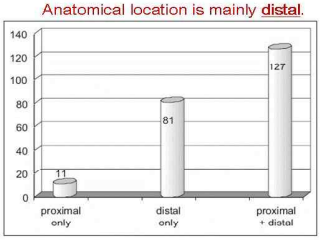
- More common
- Affects younger individuals
- No gender difference
- Faster progress
- Multiple-segmental
- More distal (aorto-iliac arteries less frequently involved)
- More aggressive

Characteristics of Diabetic Vasculopathy

- Occlusive disease is widespread
- Anatomical location is mainly distal
- Arterial wall calcification
- Occlusion > Stenosis

Characteristics of Diabetic Vasculopathy

Anatomical location is mainly distal.



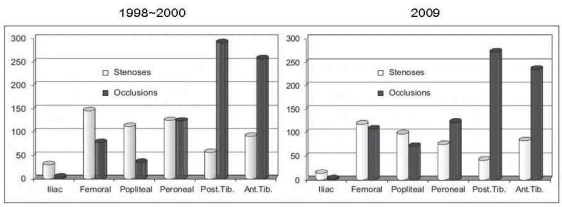
Obstructions localization in diabetic patients with CLI

Paglia E. Int J Low Extrem Wounds. 2011 Sep;10(3):152-66.

→ Increased proximal fistula

Characteristics of Diabetic Vasculopathy

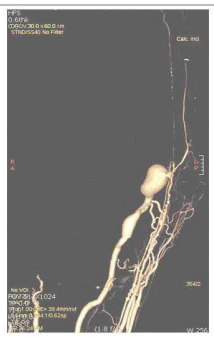
- Occlusion > Stenosis



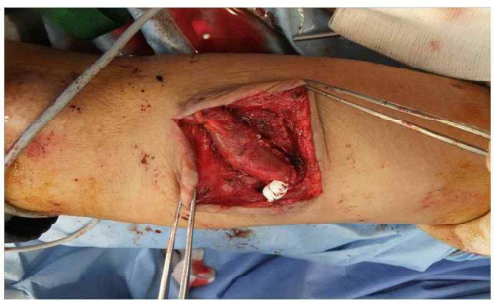
Type and distribution of the obstruction in diabetic patients with CLI

Paglia E. Int J Low Extrem Wounds. 2011 Sep;10(3):152-66.

Arterial steal phenomenon



Arterial steal phenomenon
-Tx.-



Smoking

- Higher incidence of early and late fistula failure in smoker

1. Wetzig GA, Gough IR, Furnival CM. One hundred cases of arteriovenous fistula for haemodialysis access: the effect of cigarette smoking on patency. *Aust N Z J Surg 1985;55:551-4.*
2. Monroy-Cuadros M, Yilmaz S, Salazar-Bañuelos A, Doig C. Risk factors associated with patency loss of hemodialysis vascular access within 6 months. *Clin J Am Soc Nephrol 2010;5:1787-92.*
3. Erkut B, Unlü Y, Ceviz M, Recit N, Ates, A, Colak A, et al. Primary arteriovenous fistulas in the forearm for hemodialysis: Effect of miscellaneous factors in fistula patency. *Ren Fail 2006;28:275-81.*
4. Gheith OA, Kamal MM. Risk factors of vascular access failure in patients on hemodialysis. *Iran J Kidney Dis 2008;2:201-07.*

Hypotension

- Postdialysis hypotension → poor outcome
- Predialysis diastolic pressure; a predictor of risk of thrombosis
- Low mean diastolic pressure → poor AVF survival
- Systolic pressure; not related to access survival

Body mean index

- Obesity; body mass index(BMI) > 30Kg/m^2
- Too deep superficial vein → superficialization or liposuction
- Preoperative mapping
- Chan et al; BMI <30 *vs* >30Kg/m^2 → *not* factor in predicting AVF revision or failure
- Increased risk of failure to mature ; BMI >35Kg/m^2
  → "Super obesity"

Previous dialysis catheter insertion

→ "Thrombosis of axillary & subclavian veins (ASVT)"

Incidence & Prevalence

"Thrombosis of axillary & subclavian veins (ASVT)"

- 5% of all DVT
- cause
  - Catheter-induced; 1/3 of upper extremity DVT
  - Effort thrombosis
  - Thorasic outlet syndrome
  - Thorasic tumor
  - Congestive heart failure
  - Trauma
- catheter-induced ASVT -- iatrogenic cause
  - increase in the use of subclavian vein
    - Hemodynamic monitoring
    - Parenteral nutrition
    - Pacemaker
    - Acute hemodialysis

Pathogenesis

- risk of catheter-induced thrombosis ↑
  - catheter placement ↑
  - duration of catheterization ↑
  - composition & stiffness of the catheter
  - composition of infusate
  - indication for placement of catheter
- Virchow's triad
  - **intimal injury**
  - **stasis**
  - **hypercoagulability**

Pathogenesis – *Intimal injury*

1. catheter placement → intimal injury
   - the only & the strongest predictor of ASVT; odds ratio 7.3
   - Seldinger technique;
     - needle → wire → dilator → catheter

intimal injury
↓
PLT deposition
↓
thrombus formation
↓
propagation & occlusion

Pathogenesis – *Intimal injury*

2. contact with vein wall
3. long catheter
4. catheter movement
5. catheter material

→ intimal injury ↑

- polyethylene, polyvinyl chloride >> polyurethane, silicone elastomer (Silastic)

6. hypertonic or irrigating infusate
7. balloon thrombectomy

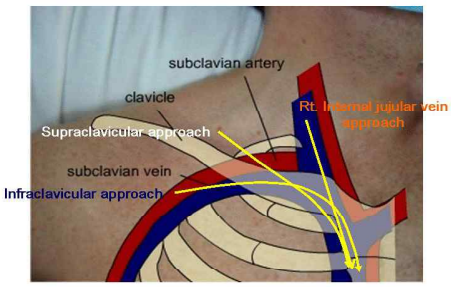
Pathogenesis – *Stasis*

- catheter placement
  - → disruption of normal flow
  - → turbulance & stasis
  - → thrombosis
- size of catheter
- length of catheter
- congestive heart failure

Pathogenesis – *Hypercoagulability*

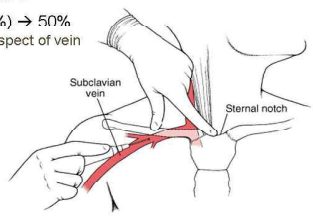
- malignancy
- prolonged parenteral nutrition
- inherited thromobophilia
  - lupus anticoagulant
  - anticardiolipin antibodies
  - etc

Subclavian Catheterization



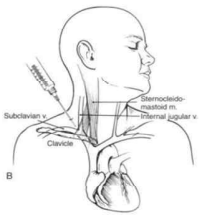
Subclavian Catheterization – *Infraclavicular approach*

- Convenient for both physicians and patients
- Easily hidden under clothing
- Infection / neurovascular Cx. ↓
- Risk of late stenosis (>70%) → 50%
  - Pressure on the caudal aspect of vein → cumulative trauma



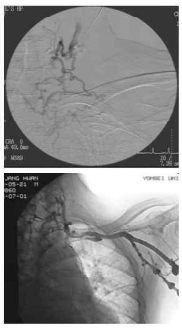
Subclavian Catheterization – *Supraclavicular approach*

- Patient acceptance; good
- Catheter position; not affected by arm and neck movement
- Intravascular lie = int. jugular cath. → less late stenosis
- Inadvertent arterial catheterization, hemorrhage, pneumothorax, damage to the large lymphatic duct



Clinical presentation

- ASVT; 30% of subclavian vein catheterization
- < 5% of ASVT; Sx(+)
  - collateral
- edema of the ipsilateral arm
- pain in arm and shoulder
- signs
  - dilated superficial vein
  - thrombophlebitis
  - etc



Diagnosis of ASVT

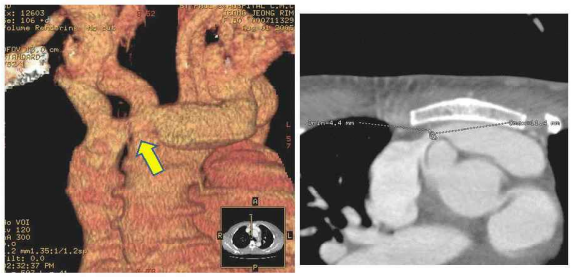
- Sign & symptoms of ASVT + Hx. of catheterization
  → certain diagnosis
- Duplex scanning, CT, MRI, venography
  → confirmation
- Duplex scanning; nearly 100% sensitivity & specificity
- Contrast venography; "Gold standard"
  → extent of thrombosis or stenosis, location of collateral veins

Diagnosis – *Venography*

- Subclavian vein thrombosis & axillary vein stenosis

Diagnosis – *CT Venography*

- Lt. brachiocephalic vein stenosis



Treatment

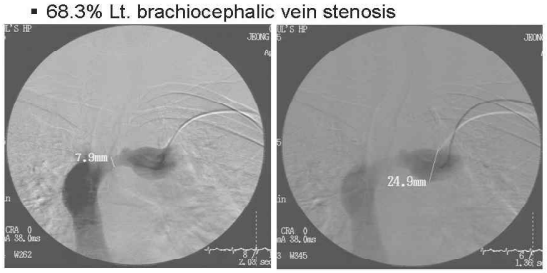
- Goals
  - Alleviate the acute symptoms
  - Prevent complication
  - Minimize late sequelae
- Asymptomatic patient without complication
  → no treatment
- Edema
  → catheter removal + extremity elevation + systemic anticoagulation

Treatment - *anticoagulation*

- IV heparin or LMWH
  - Arrest the propagation of thrombus
  - Prevent the obstruction of collateral vein
- Wafarin
  - For 3 months
  - Injury healing & thrombus organization
- Septic thrombophlebitis
  - catheter removal + systemic antibiotics + systemic anticoagulation(enoxaparin) + thrombolytic agent
- Subclavian vein stenosis
  - Balloon angioplasty (8~12mm, 12~15 atm) ± stent insertion

Treatment – *Lt. brachiocephalic vein stenosis*

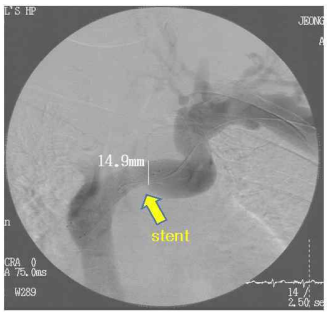
- 68.3% Lt. brachiocephalic vein stenosis



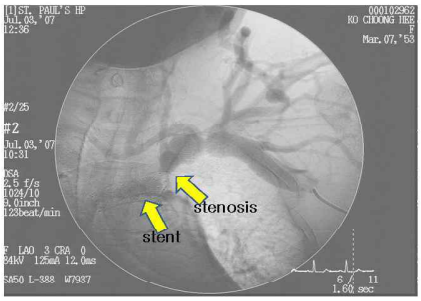
Treatment – *Lt. brachiocephalic vein stenosis*

- Balloon angioplasty alone
  - → initially successful in most case
  - → fibrotic nature and elastic recoil property
  - → failure rate 30%
- Balloon angioplasty + stent
  - → improve initial success rate; 1-month patency rate ;90%
  - → long-term success; 1-year patency rate; 25%

Treatment – *Lt. brachiocephalic vein stenosis*



Treatment – *Lt. brachiocephalic vein stenosis*



Prevention

- Meticulous catheter insertion technique
  - Reduce the number of placement attempts
  - Minimize endothelial injury
  - Decrease the contamination risk
- Tip of catheter; SVC at the junction with Rt. atrium
  - Dilute damaging infusate
- Catheter → diameter; small, removal; soon
- Catheter-related factors
  - Pliability, soft tip, smooth surface
  - Heparin-bonded catheter; 44% → 8%

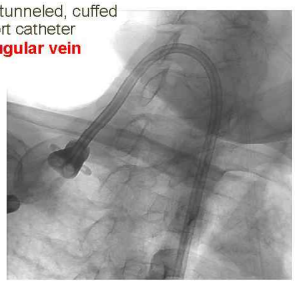
Prevention

- Prophylactic low-level anticoagulation
  - Heparin; 1000 units/L infusate
  - Low-dose warfarin (1mg/day); ?
- The best therapy for catheter-induced ASVT

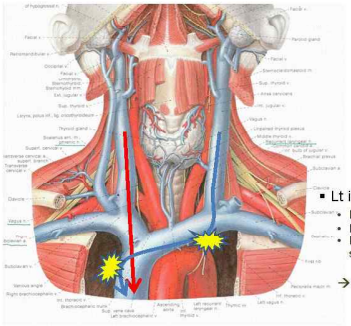
  → **"Prevention"**

Prevention

- K/DOQI 2006 Vascular Access guideline
  - The preferred insertion site for tunneled, cuffed venous dialysis catheters or port catheter systems is the **right internal jugular vein**



Prevention

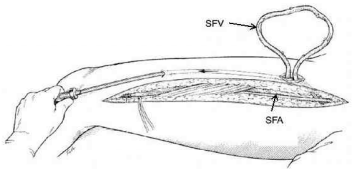


- Lt int.jugular vein cath.
  - Poorer blood flow
  - Longer catheter
  - Lie same with infraclavicular subclavian approach

→ thrombosis, stenosis ↑

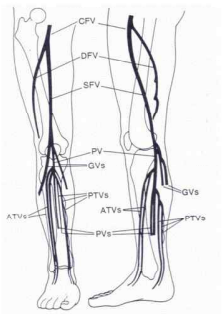
Secondary/tertiary autogenous fistula
- lower extremity -

1. Lower extremity femoral-great saphenous vein access
   ; transposition – straight or loop
2. Lower extremity femoral-superficial femoral vein access
   ; transposition



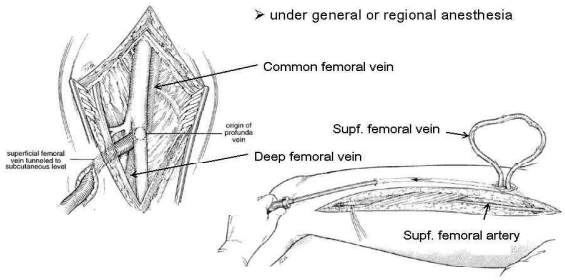
심부정맥 사용 동정맥루

1. Superficial femoral vein translocation
2. Superficial femoral vein transposition

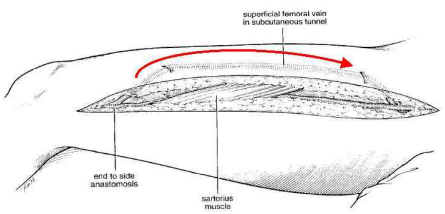


심부정맥 사용 동정맥루

➢ under general or regional anesthesia



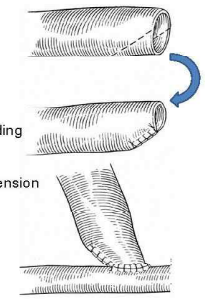
심부정맥 사용 동정맥루



✓ Supf. femoral vein; not enough length →loop(x), straight(o)

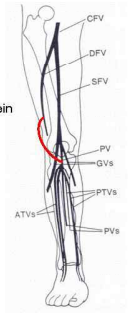
심부정맥 사용 동정맥루
- Complications -

1. 'Steal' ischemia
   - distal femoral artery > CFA
   - ASO or stiffness(calcification)
   - size mismatch;
     ; 8mm → 4.5~5mm vein tapering >> banding
2. Compartment syndrome
   - ∵ ischemia-reperfusion and venous hypertension
   - ∵ steal and venous hypertension
3. Venous hypertension



Venous hypertension

1. Deep femoral vein ↔ popliteal vein; 38%
2. Deep femoral vein ↔ tributary to the popliteal vein; 18%
3. Prevention of venous hypertension
   - Preserve the junction with deep femoral & common femoral vein
   - Preserve popliteal vein
4. *J Vasc Surg 1997;25:255~70* -- 41 patients harvesting of SFV
   - 4 patients with permanent limb edema controlled with compression stocking
   - No patient with venous ulcer



Conclusions

Nonmodifiable factor	*Level of best evidence*	*Best evidence suggests effect on patency*
Increased age	Meta-analysis[2]	Yes
Female sex	Meta-analysis[5]	No
Diabetes	Prospective series[6,7]	Yes
Hypotension	Prospective series[12,13]	Yes
Artery diameter	Meta-analysis[28]	Yes
Arteriosclerosis	Prospective series[29,30]	Yes
Arterial low	Prospective series[31-33]	Yes
Venous diameter	Meta-analysis[28]	Yes
Venous distensibility	Prospective eries[31,34]	Yes