Rescue Strategy for Coronary Perforation during Complex CHIP PCI

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Conflict of Interest

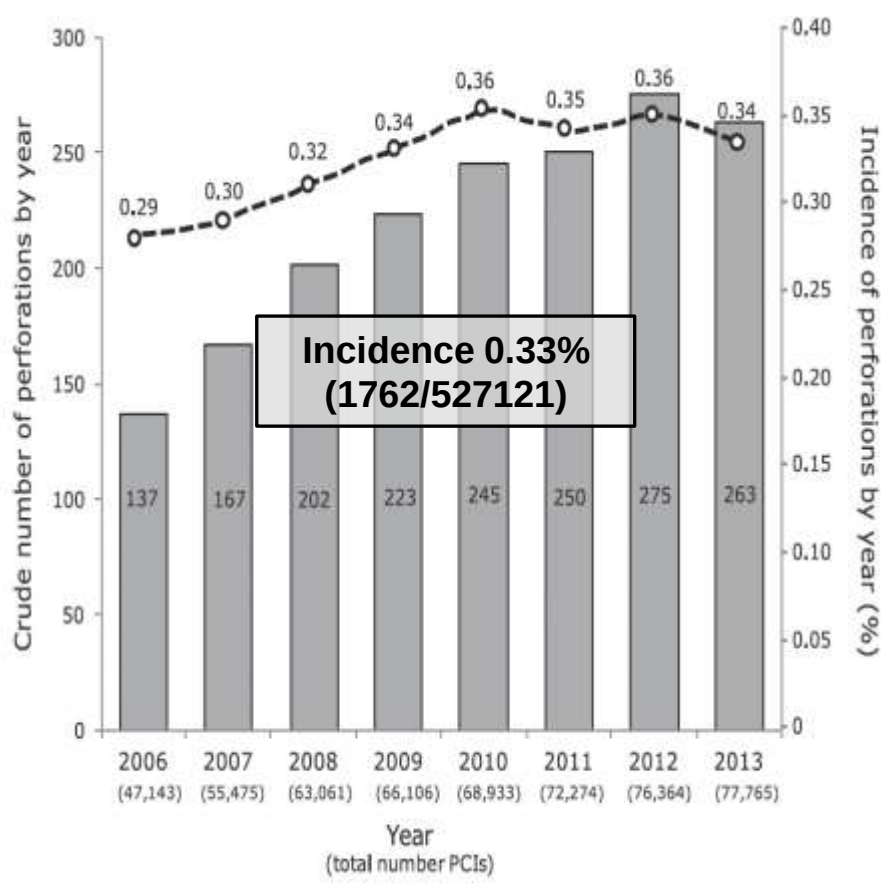
- I have nothing to disclose

Coronary perforation

- Rare but lethal complication of PCI.
- The risk for coronary artery perforation is **directly proportional to the complexity of the PCI procedure.**
  (PCI ~0.5% versus CTO intervention ~8.9%)
- In-hospital mortality rate: ~10%

Kinnaird T. et al. Circ Cardiovasc Interv 2016;9:e003449
Hirai T. et al. J Am Coll Cardiol Intv 2019;12:1902-1912

Coronary perforation in UK database



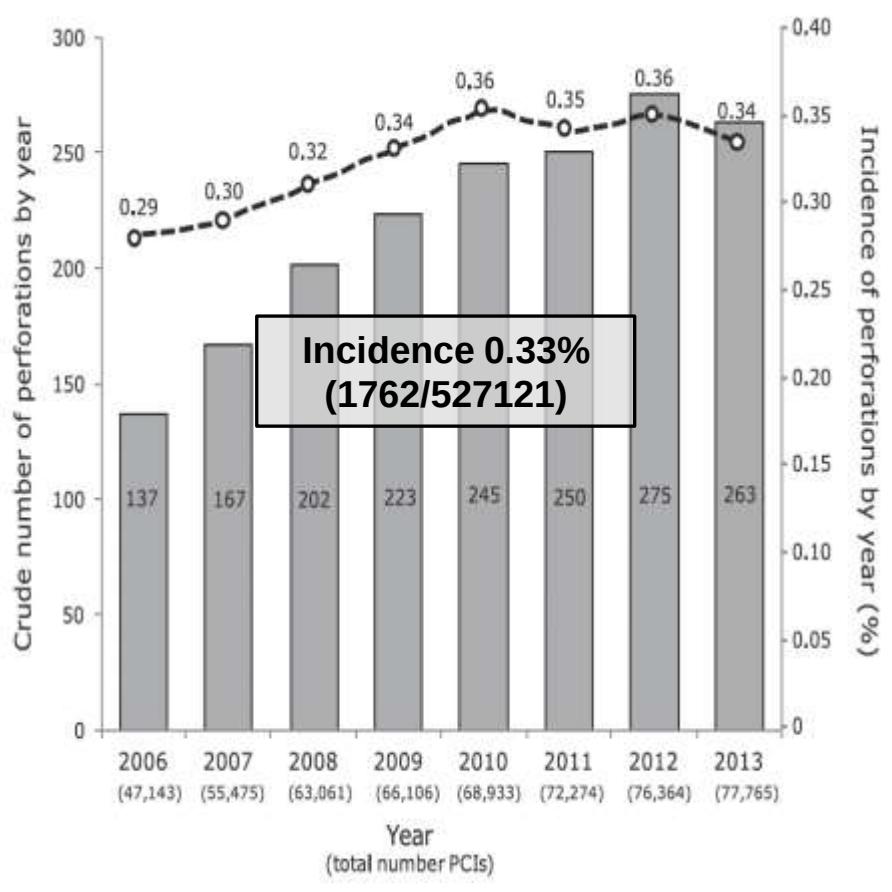
-Incidence of coronary perforation-

Factors associated with coronary perforation		
	OR (95% CI)	***p***
Age per y	1.02 (1.02-1.03)	<0.001
Male sex	0.76 (0.67-0.87)	<0.001
Hypercholesterolemia	1.16 (1.01-1.33)	0.035
Previous CABG	1.44 (1.17-1.77)	<0.001
Shock	0.60 (0.38-0.92)	0.021
Left main PCI	1.54 (1.21-1.96)	0.001
Chronic occlusions	3.96 (3.28-4.78)	<0.001
Rotational atherectomy	2.37 (1.80-3.11)	<0.001
Side branch occlusion	4.07 (2.93-5.67)	<0.001
Coronary dissection	3.31 (2.78-3.94)	<0.001
NSTEMI indication	1.26 (1.07-1.47)	0.004

-Procedural variables by perforation-

Kinnaird T. et al. Circ Cardiovasc Interv 2016;9:e003449

Coronary perforation in UK database



Clinical outcomes by perforation status

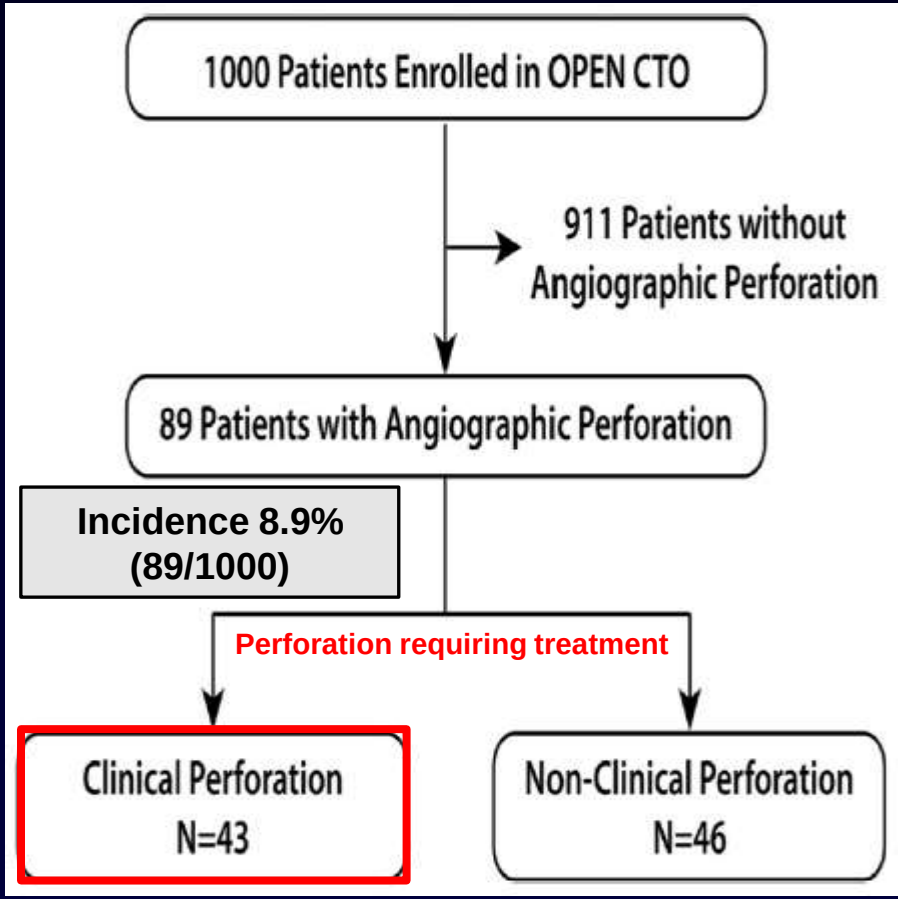
	No perforation (n=525359)	Perforation (n=1762)	*p*
In-hospital MACE	10705 (2)	406 (26)	<0.001
In-hospital mortality	5490 (1)	145 (8)	<0.001
Mortality at 30 d	10586 (2)	185 (11)	<0.001
Mortality at 1 y	24485 (5)	244 (15)	<0.001
Mortality at 5 y	57897 (25)	402 (47)	<0.001
In-hospital bleeding	3171 (0.6)	246 (14)	<0.001
Emergent CABG	903 (0.2)	87 (6)	<0.001
Stroke	833 (0.2)	42 (3)	<0.001
Cardiac tamponade	248 (0.05)	222 (14)	<0.001
Side branch occlusion	3658 (0.7)	51 (3)	<0.001
Coronary dissection	19001 (3.6)	225 (13)	<0.001

-Incidence of coronary perforation-

-Outcomes by perforation status-

Kinnaird T. et al. Circ Cardiovasc Interv 2016;9:e003449

Coronary perforation in CTO



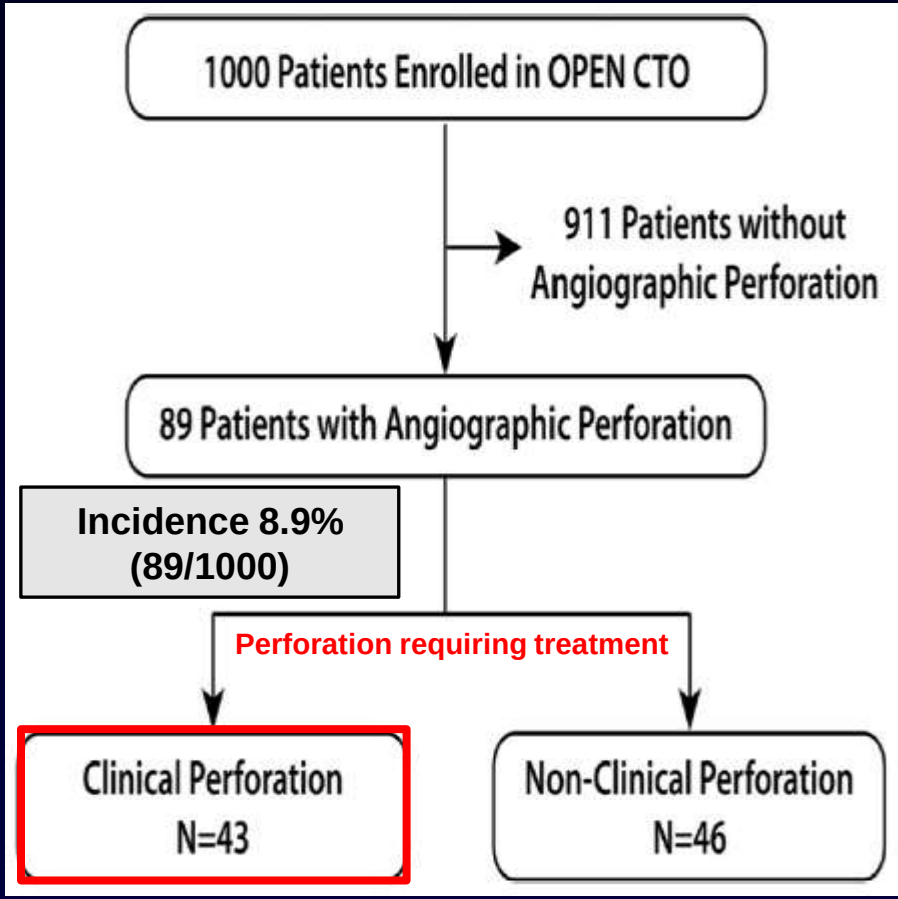
-Perforation from OPEN-CTO study-

Treatment performed for clinical perforation (n=43)	
Treatment	**n (%)**
Prolonged balloon inflation	10 (23.3)
Covered stent	12 (27.9)
Aspiration	4 (9.3)
Embolization	19 (39.5)
Pericardiocentesis	6 (14.0)
Pericardial window	4 (9.3)

-Treatment for clinical perforation-

Hirai T. et al. J Am Coll Cardiol Intv 2019;12:1902-1912

Coronary perforation in CTO



-Perforation from OPEN-CTO study-

Incidence of adverse clinical outcomes			
	Clinical perforation (n=43)	Non-clinical perforation (n=46)	*p*
Major adverse events*	22 (51.2)	3 (6.5)	<0.01
In-hospital death	9 (20.9)	0 (0.0)	<0.01
Pericardial effusion	18 (41.9)	3 (6.5)	<0.01
Cardiac tamponade	10 (23.3)	0 (0.0)	<0.01
Pericardiocentesis	6 (14.0)	0 (0.0)	0.01
Pericardial window	4 (9.3)	0 (0.0)	0.05

*In-hospital death, cardiac tamponade, and pericardial effusion

-Incidence of adverse events-

Hirai T. et al. J Am Coll Cardiol Intv 2019;12:1902-1912

Management of perforation

- General treatment approach
- Covered stents
- Coiling / Microspheres
- Others

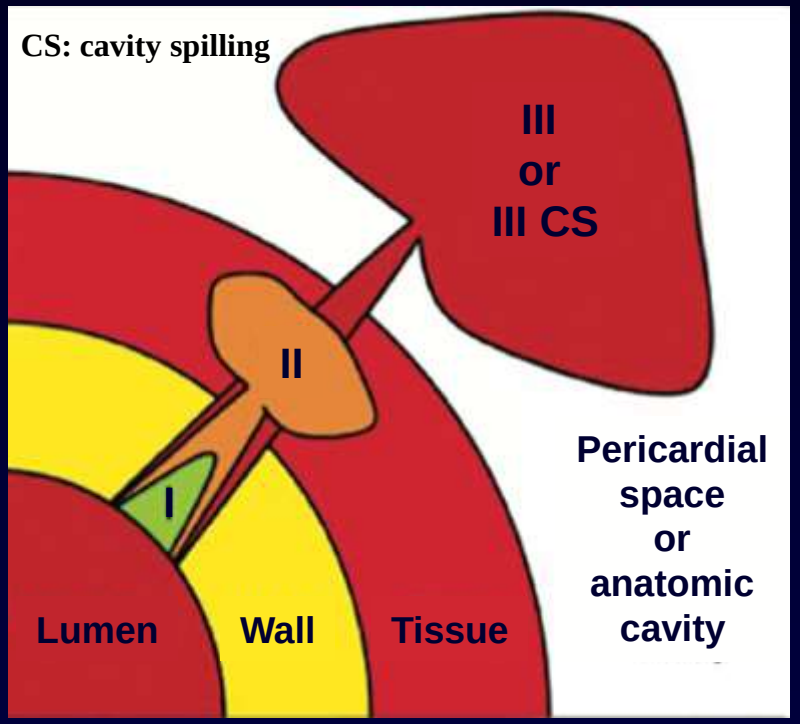
General treatment approach (1)

Management of coronary perforation depends upon

1) Site of the perforation

2) Severity of the insult

3) Hemodyanamic stability



-Perforation classification-

Ellis SG et al. Circulation 1994;90:2725-2730

General treatment approach (2)

- Call for help, echo, and prepare pericardiocentesis
- Discontinue antithrombotic agents and consider protamine
- Prolonged balloon inflation (1:1 balloon:vessel size)
  1) Allows operator to gain time.
  2) Multiple runs of prolonged balloon inflation may be needed.
  3) Many of nonlethal perforations can be treated with this conservative approach.

Lemmert ME. et al. J Am Heart Assoc 2017;6:e007049

Covered stents (1)

- Important role as bail-out treatment of coronary perforation.
- Especially located in the **proximal vessel segments** with a diameter ≥2.75mm.
- Stents covered with the biocompatible polymer polytetrafluoroethylene (PTFE) are most common.
- **Limitations of side branch occlusion and thrombosis.**

Lemmert ME. et al. J Am Heart Assoc 2017;6:e007049

Covered stents (2)

- **Graftmaster (polytetrafluoroethylene, PTFE)**

- **Papyrus (thin-strut 60um cobalt chromium stent with polyurethane covering on the abluminal side)**
  1) FDA approved (2018.09.14)
  2) Smaller size (5F compatible)
  3) Broad range of sizes (17 in total, 2.5mm~5mm)
  4) Shorter delivery time

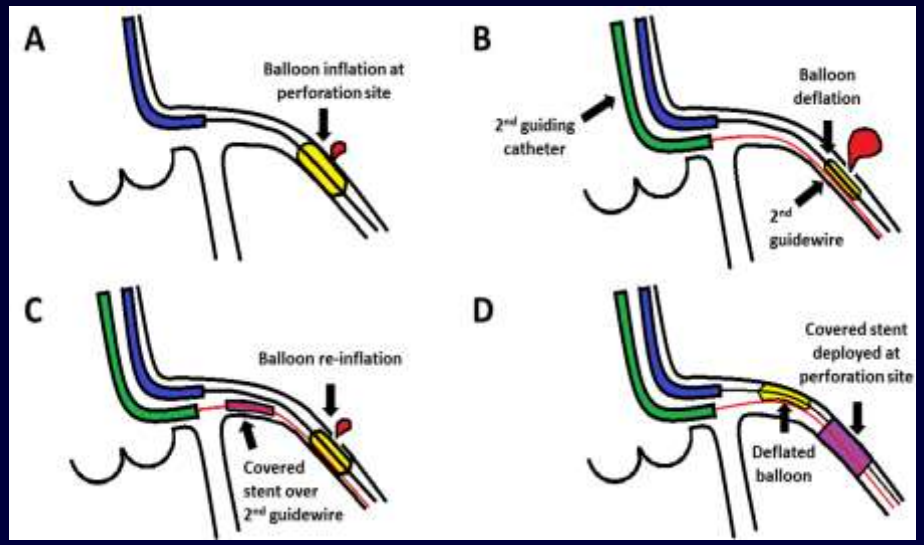
Lemmert ME. et al. J Am Heart Assoc 2017;6:e007049

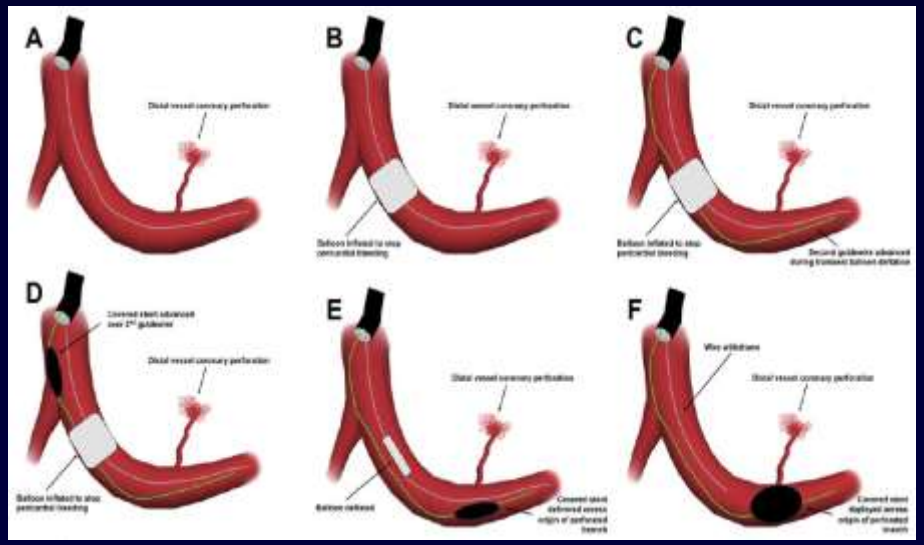
Available from BIOTRONIK website

Covered stents (3)

- Keep balloon up as much as possible

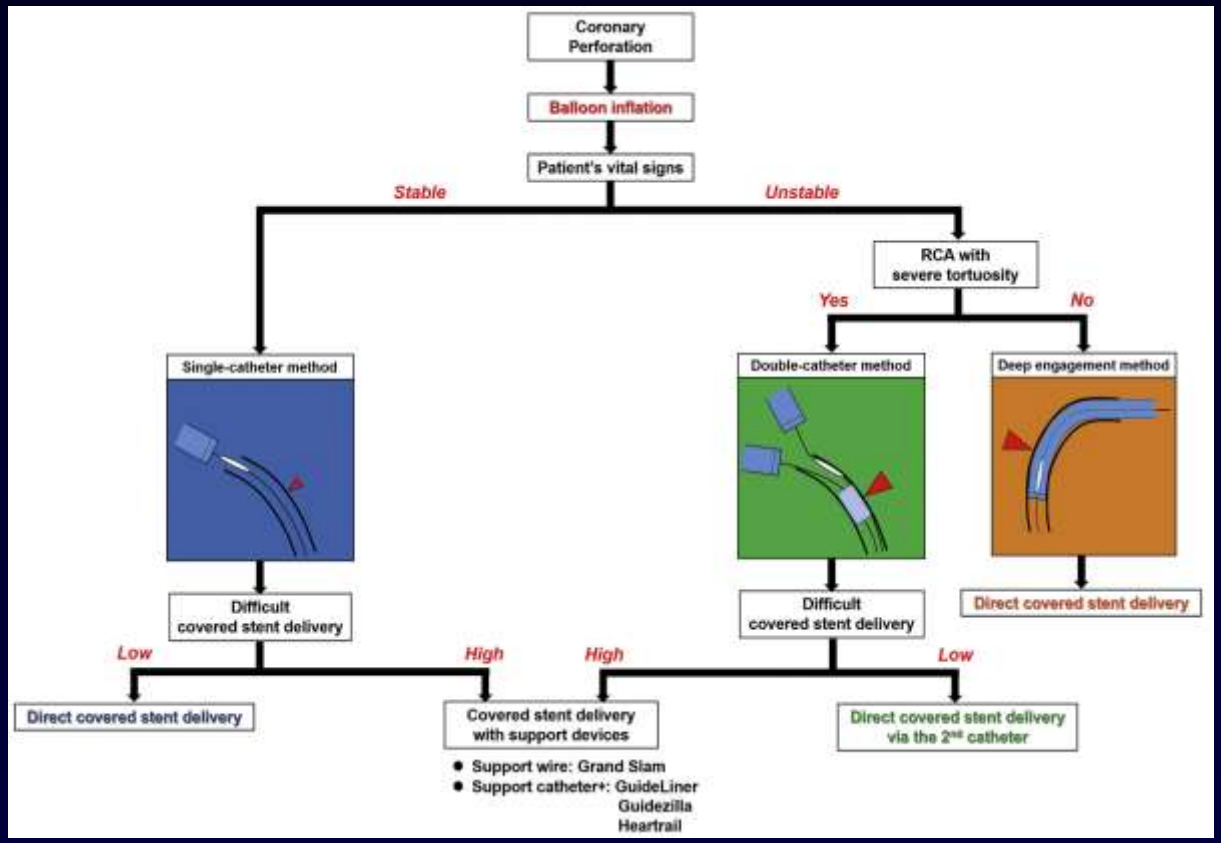
- Delivery technique
  : **Double** (ping-pong) guiding vs. **Single** guiding





Sandoval Y. et al. Catheter Cardiovasc Interv 2017;90:584-588

Covered stents (4)



- **Small perforation without hemodynamic compromise**
  → Single guiding
- **Tortuous vessel / with hemodynamic compromise**
  → Double guiding

-Catheter technique for covered stent delivery-

Giannini F. et al. J Am Coll Cardiol Intv 2018;11:1797-1810

Perforation by the vessel size (large volume center in US)

Incidence 0.51% (68/13, 339)

Mechanism of coronary perforation		
	Large vessel (n=51)	Distal vessel (n=17)
Mechanism		
Compliant balloon	12 (23.5)	0 (0.)
Non-compliant balloon	7 (13.7)	1 (5.9)
Stent	15 (29.4)	0 (0.0)
Coronary guidewire	13 (25.5)	16 (94.1)
Microcatheter	1 (2.0)	0 (0.0)
Thrombectomy catheter	1 (2.0)	0 (0.0)
Rotational atherectomy	1 (3.9)	0 (0.0)
Ellis class		
1	5 (9.8)	1 (5.9)
2	14 (27.5)	10 (58.8)
3	31 (60.8)	6 (3.53)
3-CS	1 (1.5)	0 (0.0)

-Mechanism of perforation-

Management of coronary perforation		
	Large vessel (n=51)	Distal vessel (n=17)
Management		
Pericardiocentesis in lab	11 (21.6)	2 (11.8)
Pericardiocentesis during admission	15 (29.4)	3 (17.6)
Protamine during procedure	22 (43.1)	5 (29.4)
Prolonged balloon inflation	36 (70.6)	6 (35.3)
Covered stent	14 (27.5)	2 (11.8)
Standard stent	7 (13.7)	2 (11.8)
Fat embolization	1 (2.0)	0 (0.0)
Blood clot embolization	1 (2.0)	0 (0.0)
Coli embolization	8 (15.7)	4 (23.5)
Surgical repair	1 (2.0)	0 (0.0)

-Management of perforation-

Shaukat A. et al. Catheter Cardiovasc Interv 2019;93:48-56

Coiling / Microspheres (1)

- **Coiling**

  1) Can be delivered through normal guiding catheters or microcatheters for distal and more precise placement.

  2) Coil size should be larger than the target vessel size.

- **Microspheres**

  1) Various sizes ranging from 1 to 1500 um and can be delivered through a microcatheter.

- 2) Suitable for wide range of vessel sizes.

Lemmert ME. et al. J Am Heart Assoc 2017;6:e007049

Others

- Thrombin injection
- Autologous blood clots
- Fat embolization

Lemmert ME. et al. J Am Heart Assoc 2017;6:e007049

Summary

General treatment approach
1. Inflate balloon to occlude vessel
2. IV fluids / pressors
3. Pericardiocentesis if needed
4. Notify surgeons

↓ Persistent extravasation

Large vessel perforation
1. Covered stent
2. Prolonged balloon inflation

Distal vessel perforation
1. Embolization (coil, fat, thrombin…)
2. Covered stent over perforated branch origin

↓ Continued extravasation

Surgery

Conclusion

- **Perforations are rare but an inevitable complications of complex PCI, especially during CTO intervention.**
- **Rapid assessment and knowing all available treatment modality is necessary.**
- **Respect the anatomy and always prepare for the worst.**


Dreams will
come true