

**University Hospital Acibadem City Clinic  
Sofia, Bulgaria**



**Chimneys and insitu fenestration for totally endovascular treatment of aortic arch pathology**

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**Potential conflicts of interest:**

**Speaker's name : Ivo Petrov**

- Minor shareholder
  - Kelvin Health
- Investigator honoraria
  - Medtronic
  - Contego
  - Cardiatis
- Speaking/proctoring Honoraria:
  - Medtronic
  - Contego
  - Cardiatis
  - Amgen
  - Astra Zeneca

**EAPCI**

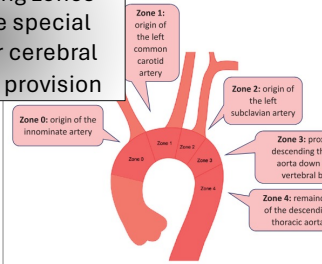
**Aortic dissection- how far are we in treatment?**

- Proximal treatment/sealing is not sufficient in 30% of the cases to isolate the false lumen leading to persisting dissection and false lumen growth in the arch and descending aorta
- Residual dissection type A with extremely compressed true lumen is a therapeutic challenge
- Up to 15% of patients after ascending aortic surgery will require re-operation involving the aortic arch
- overall operative mortality and stroke in patients undergoing distal ascending aortic or proximal arch surgery have been reported at 11.6% and 11%, respectively<sup>1</sup>

1. Williams JB, Peterson ED, Zhao Y, O'Brien SM, Andersen ND, Miller DC, et al. Contemporary results for proximal aortic replacement in North America. J Am Coll Cardiol. 2012;60:1156-62.

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**TEVAR in landing zones 1 and 0 require special techniques for cerebral vessels inflow provision**



Atkins et al. Methodist DeBakey Cardiovasc J doi: 10.14797/mdcvj.1173

Figure 3. Ichimaru classification scheme with five aortic landing zones.<sup>1</sup>

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**Hybrid approach Requires**

- CP bypass
- Partial sternotomy

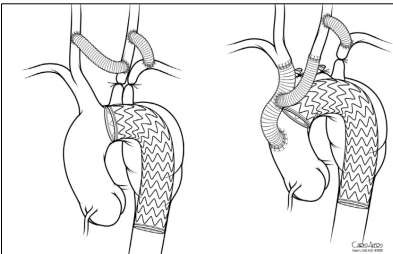


Figure 1. Hybrid aortic arch reconstruction with aortic arch replacement and bypass.

Figure 2. Zone 0 hybrid arch reconstruction with aortic branch revascularization requiring clamping and bypass from the ascending aorta.

Faulds J, Total Aortic Arch Reconstruction. Methodist DeBakey Cardiovasc J. 2016 Jan-Mar; 10(1):1-6.

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**TEVAR custom-made and on-the shelf branched and fenestrated grafts' challenges:**

- High Price
- Not always available for usage in ad-hoc procedures



Atkins and Atkins Methodist DeBakey Cardiovasc J doi: 10.14797/mdcvj.1173

Figure 6. Gore thoracic branch endograft device. GORE thoracic branch endograft © 2023.

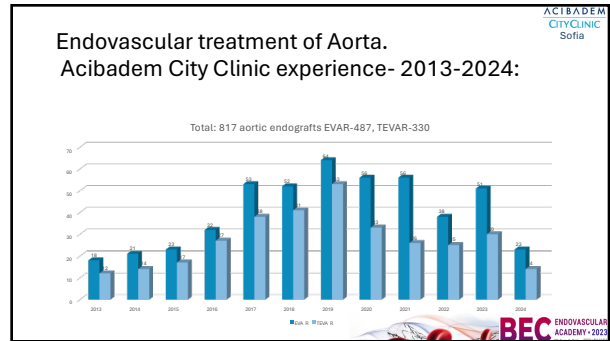
Figure 4. Tevoro Aortic Bypass Custom Medical Device. Used with permission from Tevoro Medical Corporation.

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TEVAR custom-made and on-the shelf branched and fenestrated grafts' challenges:  
 -High Price  
 -Not always available for usage in ad-hoc procedures

**Expensive**  
**Requires delay for planning and elaboration**  
**Not always available**

Atkins and Atkins Methodist DeLoake Cardiovasc. J doi: 10.14797/mj...  
 Figure 6 Gore thoracic branch endograft device. Gore thoracic branch endograft © 2023.  
 Figure 4 Torayso Aortic Relay Custom-Medical Device. Used with permission from Torayso Medical Corporation.



**Totally endovascular options (always available) for Ao Arch pathology**

- 1. Large size “aortic” bare stent implantation, across the supra-aortic vessels.
- 2. Brachiocephalic vessels chimneys assisted TEVAR
- 3. Ao Arch TEVAR across the brachiocephalic vessels immediately followed by in-situ fenestration of the aortic stent-graft and bridging stent grafts implantation

**Totally endovascular options (always available) for Ao Arch pathology**

- 1. Large size “aortic” bare stent implantation, across the supra-aortic vessels.

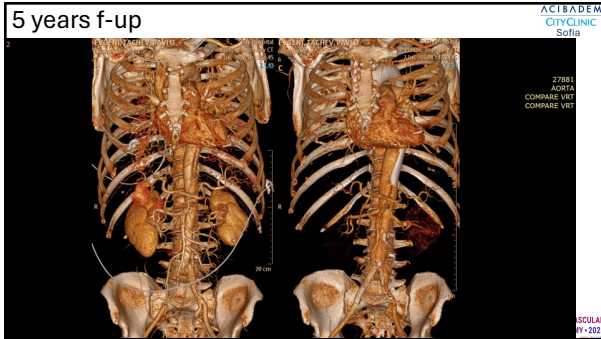
**Note:**  
 proximal part of the stent starts just on the sinotubular junction above the coronary arteries

28.9.1965 M  
 CITY HOSPITALS CLINICS  
 19/02/2017  
 Thorapheral  
 Left coronary Arteries ECG

Petrov I et al. Endovascular treatment...JACC: CARDIOVASCULAR INTERVENTIONS VOL. 11, NO. 2, 2018.

**CTA 1 year after:**  
 Excellent (normal) flow in all vessels arising from the stented zone:  
 brachiocephalic and thoracic and all vessels involved into the acute dissection: visceral, renal, lower legs )

Petrov I et al. Endovascular treatment...JACC: CARDIOVASCULAR INTERVENTIONS VOL. 11, NO. 2, 2018.



Endovascular treatment of Aorta.  
Acibadem City Clinic experience- 2013-2024:

- From 05/2019 (first Ch-TEVAR) until now 18 patients
- 4 patients with 3 chimney
- 7 patients with 2 chimney
- 7 patients with 1 chimney
- From 02/2024( first In-situ fenestration ) to Oct 2024 10 patients (50% of total TEVAR for this period)
- 3 with 1 fenestration
- 2 with 2 fenestrations
- 5 with 3 fenestrations

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Endovascular treatment of Aorta.  
Acibadem City Clinic experience- 2013-2024:

- From 05/2019 (first Ch-TEVAR) until now 18 patients
- All successful.
- 1 year Aorta related mortality 5.5%
- From 02/2024( first In-situ fenestration ) until now 10 patients(50% of total TEVAR for this period)
- Perioperative mortality 0%. One early stroke (fatal)
- 3 months Aorta related mortality 0%

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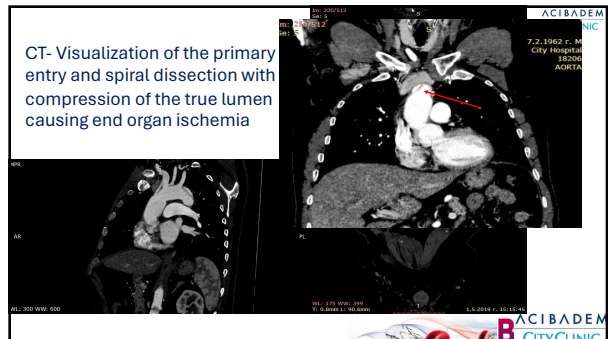
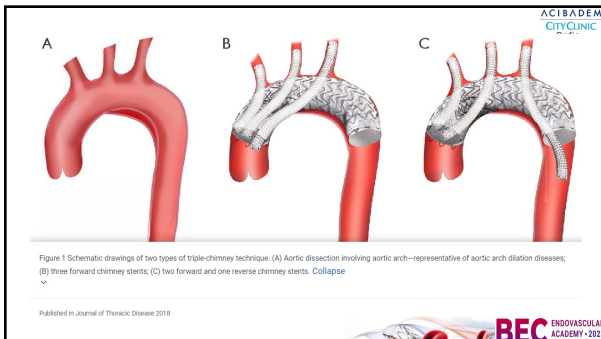
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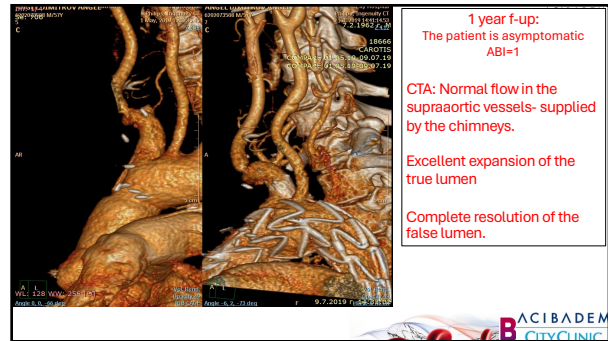
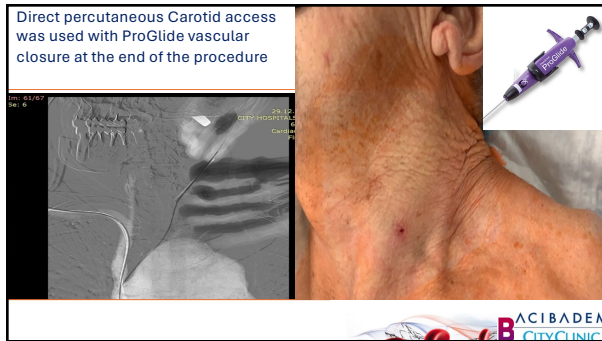
Totally endovascular options (always available) for Ao Arch pathology

- 2. Brachiocephalic vessels chimney assisted TEVAR

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Totally endovascular options (always available) for Ao Arch pathology

- 3.Arch TEVAR across the brachiocephalic vessels immediately followed by **in-situ fenestration under protection of spontaneous extraanatomical bypass to brain vessels** of the aortic stent-graft and bridging stent grafts implantation

In situ fenestration followed by bridging stent-graft implantation in the branch vessels

Table 4. Summary of operative details and follow-up outcome for in situ fenestration.

Authors	Patient number	Landing zone 0/1/2/3	Fenestration number	Stroke	Endoleak	Stent patency	Re-intervention	Follow-up mortality
McWilliams et al. <sup>17</sup>	1	Zone 2	1	0	0	1/1	0	0
Eid-Sult et al. <sup>18</sup>	1	Zone 1	1	0	0	1/1	0	0
Murphy et al. <sup>19</sup>	1	Zone 2	1	0	0	1/1	0	0
Sonesson et al. <sup>20</sup>	1	Zone 0	2	0	0	2/2	0	0
Manning et al. <sup>21</sup>	1	Zone 2	1	0	0	1/1	0	0
Hongo et al. <sup>22</sup>	1	Zone 0	1	0	0	1/1	0	0
Ahanchi et al. <sup>23</sup>	6	0/0/6/0	6	0	0	5/5	0	0
Redinger et al. <sup>24</sup>	22	2/1/19/0	22	0	0	22/22	0	2
Eslami et al. <sup>25</sup>	1	Zone 0	1	0	0	1/1	0	0
Hongo et al. <sup>26</sup>	1	Zone 0	1	0	I type II	1/1	1	0
Tse et al. <sup>27</sup>	10	1/2/5/2	10	0	0	6/6	0	0
Xiong et al. <sup>28</sup>	1	Zone 2	2	0	0	2/2	0	0
Katada et al. <sup>29</sup>	7	7/0/0/0	19	2	0	NA	0	2
Tan et al. <sup>30</sup>	1	Zone 2	1	0	0	1/1	0	0
Tsilimiparis et al. <sup>31</sup>	1	Zone 1	1	0	0	1/1	0	0
Qin et al. <sup>32</sup>	24	1/6/17/0	34	0	0	34/34	0	0
Alsa-Chaber et al. <sup>33</sup>	1	Zone 0	2	0	0	1/1	0	0
Kapralos et al. <sup>34</sup>	1	Zone 0	2	0	0	2/2	0	0
Shang et al. <sup>35</sup>	10	10/0/0/0	30	0	0	28/28	0	0
Bai et al. <sup>36</sup>	1	Zone 1	1	0	0	1/1	0	0
Wang et al. <sup>37</sup>	6	0/0/0/0	6	1	I type II	6/6	1	0

LHL, Chan YC... in situ fenestration for aortic arch... Vascular. 2020 Aug;28(4):333-341.

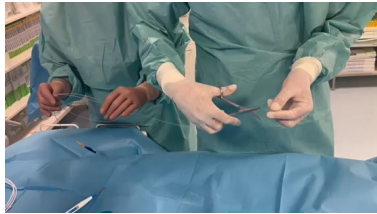
In situ fenestration in the aortic arch  
Feb-to Oct 2024 , n=10

- In 3 out of 10 patients we did a **two in-situ fenestrations**:
  - In 2 two fenestrations (LCCA and LSA)
  - In five patients three fenestrations (BCT, LCCA and LSA)
  - One failed fenestration converted to long chimney, one unsuccessful LSA was done successfully on a second procedure, one mediastinal space penetration sealed after bridging stent graft implantation
  - Periprocedural mortality 0%, one stroke

Our In-Situ fenestration protocol

- Homemade temporary extracorporeal arterio-arterial bypass: flow donor 12 F introducer in femoral artery, connection tubes to the introducers already positioned in the right axillary artery (12 F) and LCCA ( 8F) and left axillary artery.
- Aortic graft implantation, under rapid pacing (at 140-to-180 bpm).
- Fenestration procedure itself: triple coaxial system (sheath, guiding catheter, microcatheter) aiming to the stent-graft surface in two projections puncture with cutted tip and electrified Conquest Pro12.0 [3] CTO connected to "surgical" electrocatheter we apply energy for several seconds together with gentle move forward of the wire
- After snaring and externalizing the wire using "through-and-through" configuration balloon dilations with incremental coronary balloon diameters ranging from 1.5 mm to 5 mm.
- Bridging stent graft (B-graft, Bentley) with diameter corresponding in one-to-one ratio to the reference diameter of the supraaortic vessel.


1. Cutting the tip of the .014" Confianza Pro wire  
 2. Connecting the wire to electrocautery (electrified wire)



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Temporary retrograde spontaneous Flow bypass: Split toward covered LCCA and brachiocephalic




Head to head systolic pressure comparison between descending aorta (145mmHg) and covered brachiocephalic vessels (115mmHg) (Pressure index 0.79)



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Head to head systolic pressure comparison between descending aorta (145mmHg) and covered debranched brachiocephalic vessels (115mmHg) (0.79)



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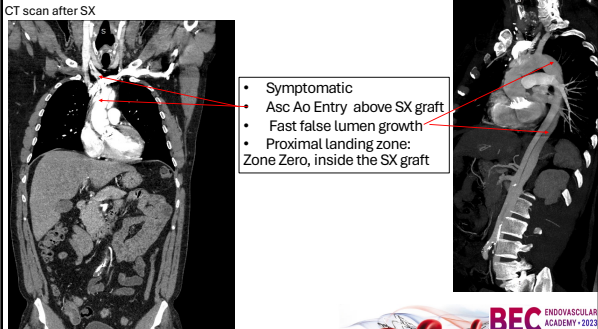
**Case report**  
**inSitu fenestration**

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- A 49-year-old male with neurological clinical symptoms with dizziness and doubled vision, chest pain in hypertensive peaks.
- Past medical history: TAAD Bentall + AVR + CABG (RCA) 3 months before
- CTA: persistent dissection flap into the ascending aorta, aortic arch, and brachiocephalic trunk and distal true lumen compression.

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CT scan after SX



- Symptomatic
- Asc Ao Entry above SX graft
- Fast false lumen growth
- Proximal landing zone: Zone Zero, inside the SX graft

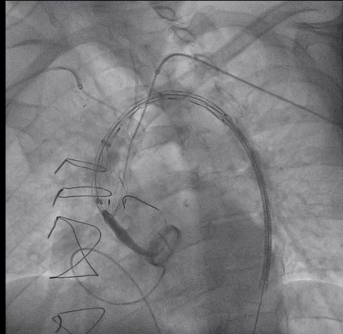
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**Redo surgery Perioperative risk scores:**

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<p><b>Patient-related factors</b></p> <p>age 65</p> <p>gender M</p> <p>diabetes long disease <input checked="" type="checkbox"/></p> <p>arterioarterial aneurysm <input checked="" type="checkbox"/></p> <p>poor mobility <input checked="" type="checkbox"/></p> <p>previous cardiac surgery <input checked="" type="checkbox"/></p> <p>stroke <input checked="" type="checkbox"/></p> <p>radioiodine ablation <input checked="" type="checkbox"/></p> <p>renal impairment <input checked="" type="checkbox"/></p> <p>previous ICC (A-D) series <input checked="" type="checkbox"/></p> <p>radiation on chest <input checked="" type="checkbox"/></p>	<p><b>Cardio-related factors</b></p> <p>CCF symptoms <input checked="" type="checkbox"/></p> <p>LV hypertrophy <input checked="" type="checkbox"/></p> <p>previous hypertension <input checked="" type="checkbox"/></p> <p>NHSA class 3</p>	<p><b>EuroSCORE II</b></p> <p><b>18.45 %</b></p> <p>Based on the information you have provided... if 1000 patients with a similar condition had a similar operation, 18.45% are expected to die. Information R to R should be expected to improve. Your EuroSCORE II is 18.45.</p>
<p><b>Operation-related factors</b></p> <p>major on thoracic aorta <input checked="" type="checkbox"/></p> <p>urgency of operation urgent</p> <p>length of operation 7 hours</p>		

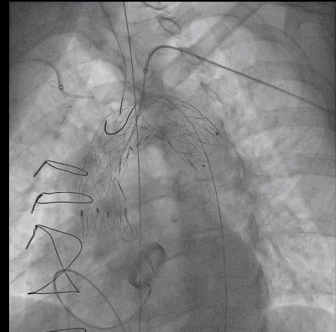
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**Ao Stent graft (Valiant Captivia) implantation**

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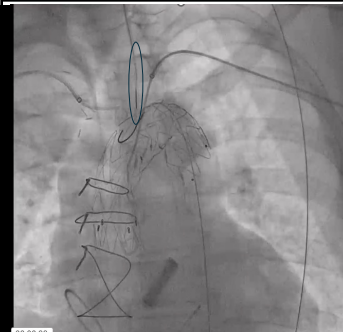


Valiant St-graft implanted landing in the asc. Ao SX graft

Multipurpose GC aiming at the stentgraft in two projections

Note! No tracheal tube  
No GA, deep but conscious sedation

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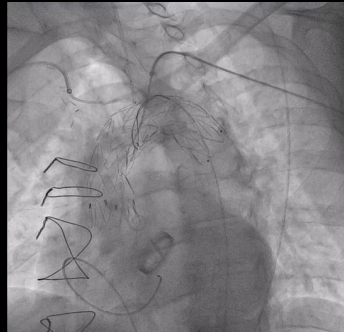


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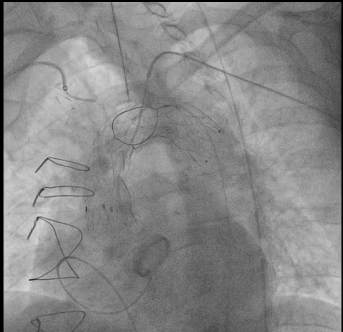
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Valiant Stgraft implanted landing in the asc. Ao surgical graft

A 25mm snare position in front of the retrogradely punctured left CCA prepared for snaring and "through and through" maneuver

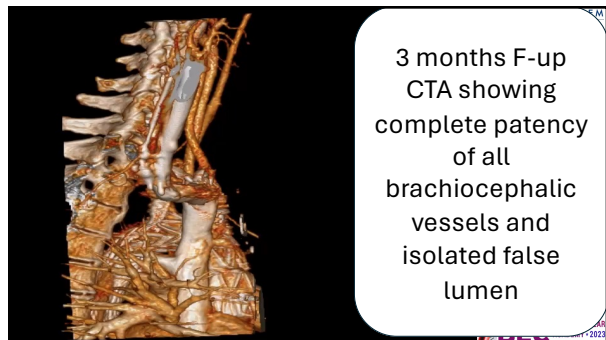
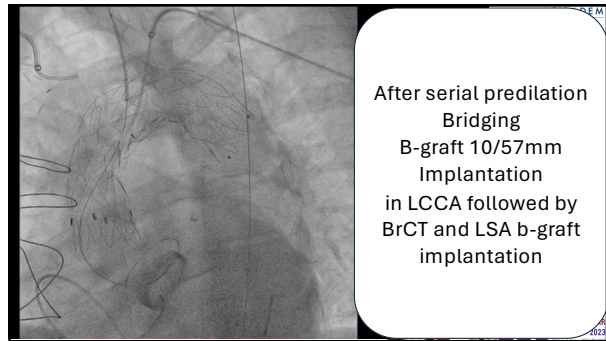
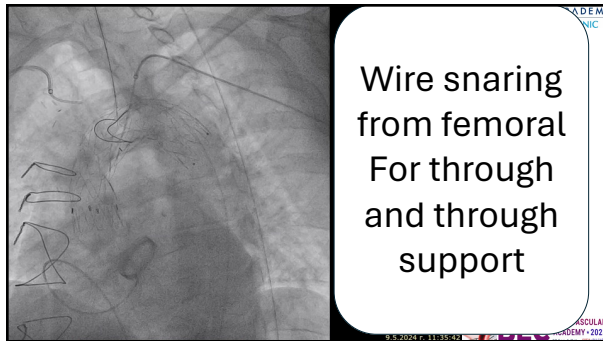
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**Electrified Wire penetration**

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Clinical case evolution:

- Uneventful 6 months follow-up
- Asymptomatic
- Totally isolated false lumen aneurysm
- Bilateral ABI 0.9

Conclusions

- Despite endovascular advances in fenestrated and branched devices, thoracic endovascular aortic repair (TEVAR) for arch pathologies remains challenging
- Parallel chimneys/snorkel and in-situ fenestration assisted total endovascular aortic arch repair is always available strategy
- In-situ fenestration technique is evolving new strategy for complex high surgical risk patients with excellent periprocedural and mid-term results in experienced aortic centers
- Long-term results are awaited to precise the proper indication for the right patient

Thank you for your attention!!!



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