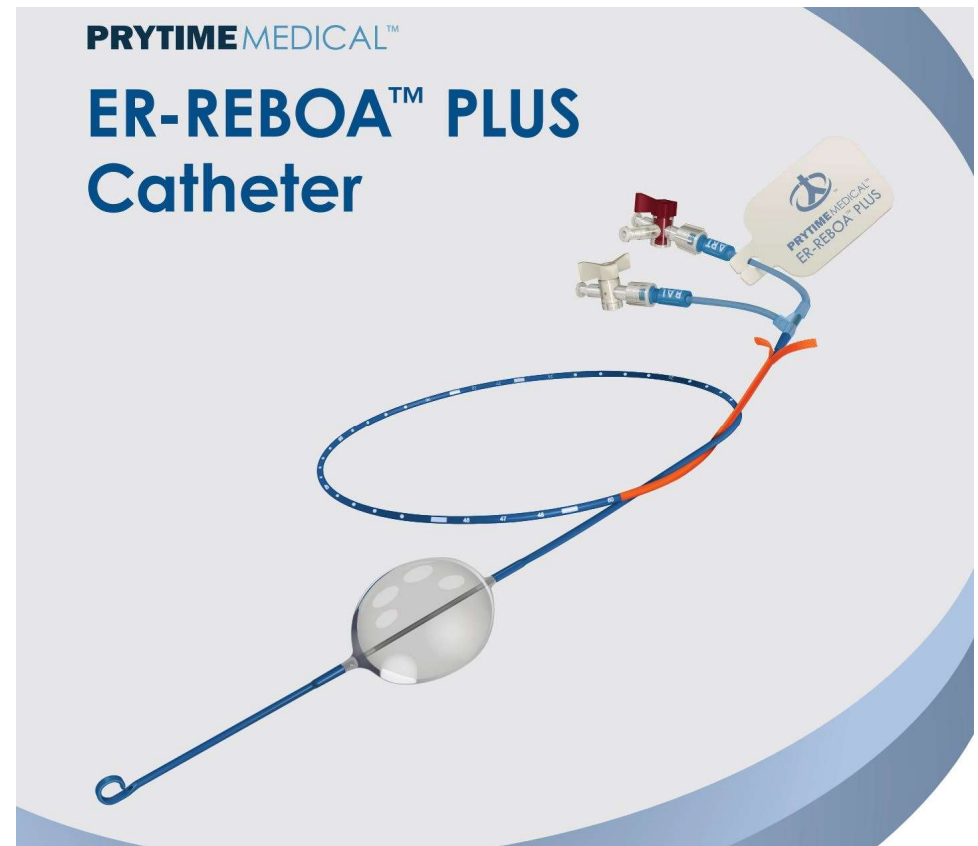# Mid Night Journal Club

大阪府済生会千里病院　千里救命救急センター
福田　将啓

2022.08.01 (Mon)

REBOA

- **R**esuscitative **E**ndovascular **B**alloon **O**cclusion of **A**orta

- 蘇生手技の一つとして、IABO (Intra-aortic Balloon Occlusion)を行うこと。

PRYTIME MEDICAL™

ER-REBOA™ PLUS Catheter

REBOAと比較される手技

- 蘇生的開胸術（RT）
  - 迅速
  - 胸部外傷に対する止血操作、閉塞性ショックの解除などが同時に可能
  - 侵襲が大きい

- 開腹大動脈圧迫
  - 比較的迅速
  - 腹部の止血操作に移行できる

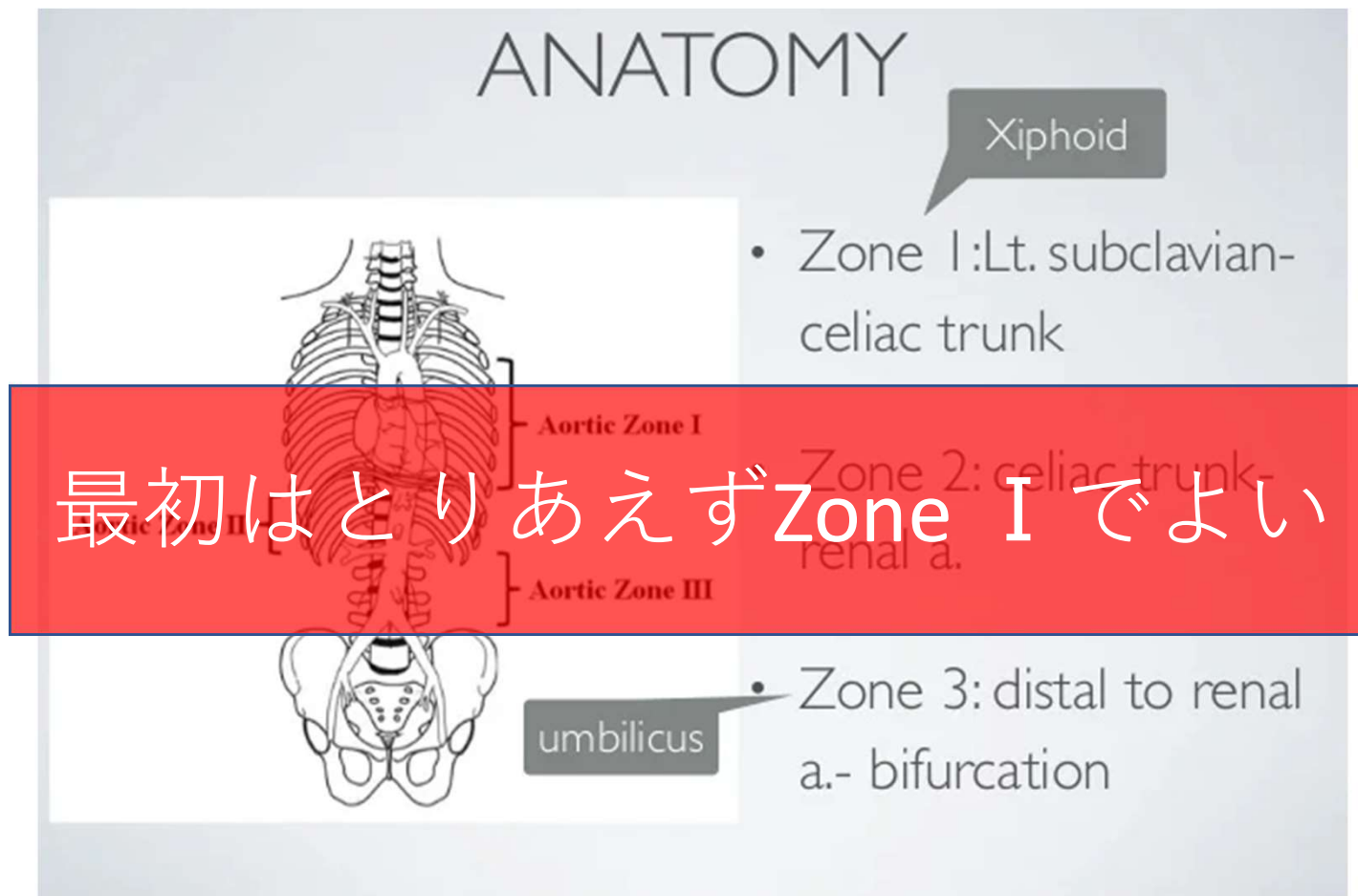# REBOAの適応

- 外傷性出血性ショック
- 腹部大動脈瘤破裂
- 産科危機的出血
- 消化管出血
- 内臓動脈瘤破裂

- 内因性心肺停止

REBOAの留置方法

- 大腿動脈、上腕動脈にシースを留置
- バルーンカテーテルを目的留置血管まで進める

最初はとりあえずZone Ⅰ でよい

REBOAの管理

- Zone I での完全遮断は20-30分以内にとどめるべき

- 必要に応じてZoneの変更を考慮する

- partial REBOA、intermittent REBOAにより、臓器虚血を軽減できる可能性がある

・・・・でエビデンスどうなの？

REBOAか RTか

Resuscitative Endovascular Balloon Occlusion of the Aorta and Resuscitative Thoracotomy in Select Patients with Hemorrhagic Shock: Early Results from the American Association for the Surgery of Trauma's Aortic Occlusion in Resuscitation for Trauma and Acute Care Surgery Registry

Brenner, Megan MD, FACS[a,*]; Inaba, Kenji MD, FACS[b]; Aiolfi, Alberto MD[b]; DuBose, Joseph MD, FACS[a]; Fabian, Timothy MD, FACS[c]; Bee, Tiffany MD, FACS[c]; Holcomb, John B. MD, FACS[d]; Moore, Laura MD, FACS[d]; Skarupa, David MD, FACS[e]; Scalea, Thomas M. MD, FACS[a] for the AAST AORTA Study Group

Methods

- AORTA(Aortic Occlusion for Resuscitation in Trauma and Acute Care Surgery) study
- 多施設、前向き研究
- 2013年11月〜2017年1月

<Inclusion>
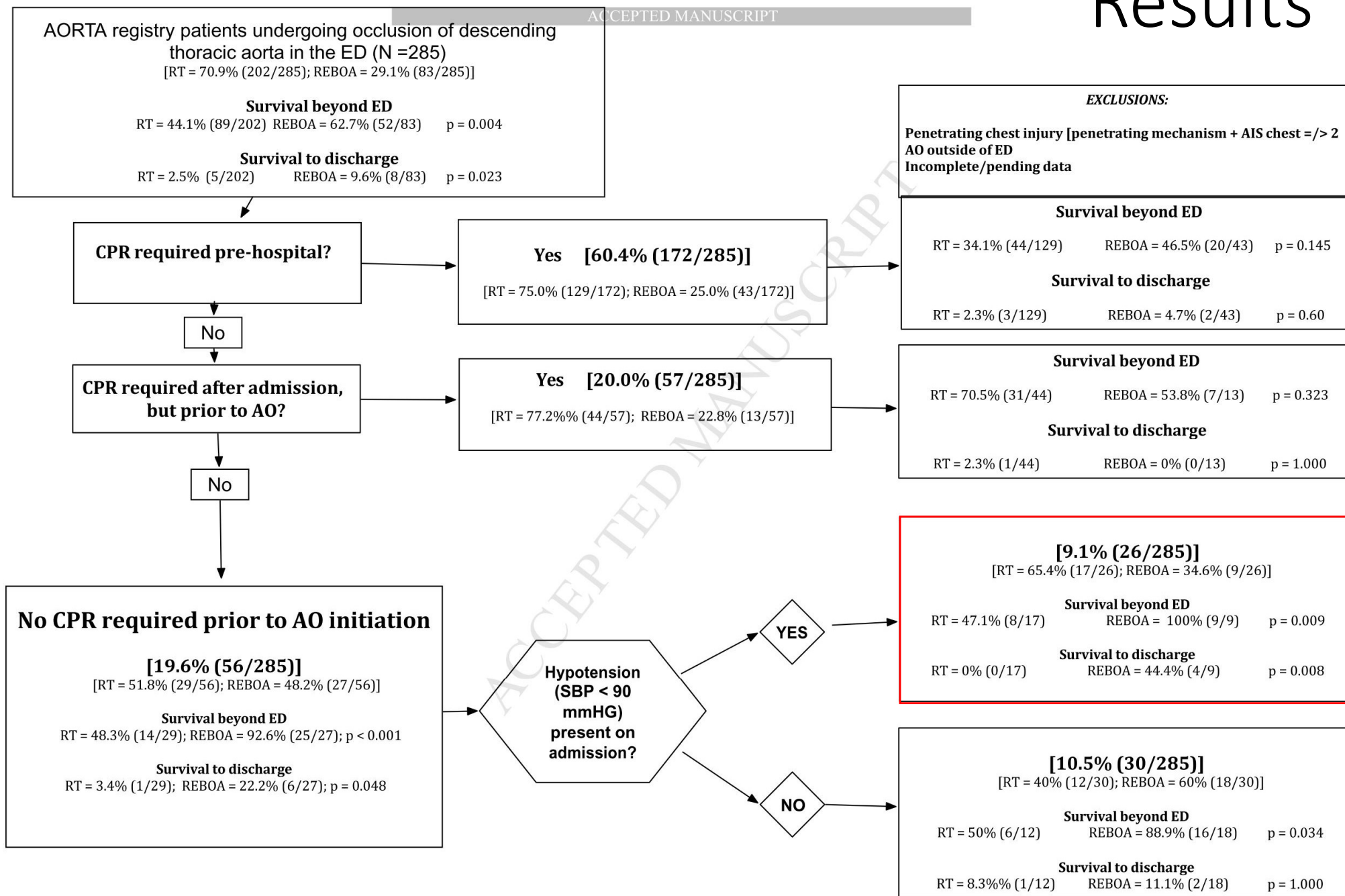
- 18歳以上

<Exclusion>

- 胸部鋭的外傷単独症例、データ欠落

Megan Brenner, et al. Resuscitative Endovascular Balloon Occlusion of the Aorta and Resuscitative Thoracotomy in Select Patients with Hemorrhagic Shock: Early Results from the American Association for the Surgery of Trauma's Aortic Occlusion in Resuscitation for Trauma and Acute Care Surgery Registry. J Am Coll Surg. 2018 May; 226(5):730-740.

Results

AORTA registry patients undergoing occlusion of descending thoracic aorta in the ED (N =285)
[RT = 70.9% (202/285); REBOA = 29.1% (83/285)]

Survival beyond ED
RT = 44.1% (89/202) REBOA = 62.7% (52/83) p = 0.004

Survival to discharge
RT = 2.5% (5/202) REBOA = 9.6% (8/83) p = 0.023

EXCLUSIONS:

Penetrating chest injury [penetrating mechanism + AIS chest =/> 2
AO outside of ED
Incomplete/pending data

CPR required pre-hospital?

No

CPR required after admission, but prior to AO?

No

No CPR required prior to AO initiation

[19.6% (56/285)]
[RT = 51.8% (29/56); REBOA = 48.2% (27/56)]

Survival beyond ED
RT = 48.3% (14/29); REBOA = 92.6% (25/27); p < 0.001

Survival to discharge
RT = 3.4% (1/29); REBOA = 22.2% (6/27); p = 0.048

Yes   [60.4% (172/285)]

[RT = 75.0% (129/172); REBOA = 25.0% (43/172)]

Survival beyond ED
RT = 34.1% (44/129) REBOA = 46.5% (20/43) p = 0.145

Survival to discharge
RT = 2.3% (3/129) REBOA = 4.7% (2/43) p = 0.60

Yes   [20.0% (57/285)]

[RT = 77.2%% (44/57); REBOA = 22.8% (13/57)]

Survival beyond ED
RT = 70.5% (31/44) REBOA = 53.8% (7/13) p = 0.323

Survival to discharge
RT = 2.3% (1/44) REBOA = 0% (0/13) p = 1.000

Hypotension (SBP < 90 mmHG) present on admission?

YES

[9.1% (26/285)]
[RT = 65.4% (17/26); REBOA = 34.6% (9/26)]

Survival beyond ED
RT = 47.1% (8/17) REBOA = 100% (9/9) p = 0.009

Survival to discharge
RT = 0% (0/17) REBOA = 44.4% (4/9) p = 0.008

NO

[10.5% (30/285)]
[RT = 40% (12/30); REBOA = 60% (18/30)]

Survival beyond ED
RT = 50% (6/12) REBOA = 88.9% (16/18) p = 0.034

Survival to discharge
RT = 8.3%% (1/12) REBOA = 11.1% (2/18) p = 1.000

Megan Brenner, et al. Resuscitative Endovascular Balloon Occlusion of the Aorta and Resuscitative Thoracotomy in Select Patients with Hemorrhagic Shock: Early Results from the American Association for the Surgery of Trauma's Aortic Occlusion in Resuscitation for Trauma and Acute Care Surgery Registry. J Am Coll Surg. 2018 May; 226(5):730-740.

Table 1. Pre-Hospital Demographics: Admission Variables and Intervention Details for all Patients Undergoing Zone 1 Aortic Occlusion in the Emergency Department

Variable	Total (N = 285)	REBOA (N = 83)	RT (N = 202)	p Value
Age, y, mean ± SD	39.8 (17.4)	44.6 (20.2)	37.8 (15.7)	0.008
Male sex, n (%)	81.8	65 (78.3)	168 (83.2)	0.335
Penetrating mechanism, n (%)	41.4	14 (16.9)	104 (51.5)	< 0.001
Blunt mechanism, n (%)	58.6	69 (83.1)	98 (48.5)	< 0.001
ISS, mean ± SD	38.2 (18.9)	35.1 (16.5)	34.7 (20.0)	0.908
Head AIS, mean ± SD	3.1 (2.1)	3.2 (1.9)	2.9 (2.1)	0.448
Chest AIS, median (IQR)	2.6 (1.9)	2.5 (1.7)	3.0 (2.0)	0.117
Field GCS, median (IQR)	4.8 (3.8)	5.1 (3.9)	4.6 (3.8)	0.434
Pre-hospital CPR required, n (%)	172 (60.4)	43 (51.8)	129 (63.9)	0.059
Admission GCS, median (IQR)	3 (0)	3 (0)	3 (3)	0.118
Duration of CPR required, min, mean ± SD	21.8 (13.8)	21.5 (12.5)	21.9 (14.2)	0.880
Admission hemoglobin, mean ± SD	10.7 (2.5)	10.6 (2.3)	10.5 (2.6)	0.779
Admission hematocrit, mean ± SD	32.3 (7.8)	31.9 (7.0)	31.9 (7.4)	0.996
Admission INR, median (IQR)	1.8 (1.0)	1.8 (1.2)	2.0 (1.3)	0.341
AO initiation physiology				
SBP, mmHg, median (IQR)	0 (0)	0 (55)	0 (0)	<0.001
AO physiologic response				
Post-occlusion SBP, mmHg, mean ± SD	47 (61)	89 (65)	30 (51)	<0.001
Duration of AO, min, median (IQR)	20.0 (30)	31.0 (57)	19.0 (21)	0.002
Adjunctive procedures required, n (%)				
Pelvic binder	23 (8.1)	13 (15.7)	10 (5.0)	0.003
Exploratory laparotomy	103 (36.1)	41 (49.9)	62 (30.7)	0.003
Hepatic packing	31 (10.9)	13 (15.7)	18 (8.9)	0.096
Pelvic packing	21 (7.4)	6 (7.2)	15 (7.4)	0.954
Hepatic resection	4 (1.4)	3 (3.6)	1 (0.5)	0.076
Splenectomy	11 (3.9)	7 (8.4)	4 (2.0)	0.016
Bowel resection	15 (5.3)	5 (6.0)	10 (5.0)	0.772
Craniectomy/craniotomy	3 (1.1)	3 (3.6)	0 (0)	0.024
Pelvic external fixation	2 (0.7)	1 (1.2)	1 (0.5)	0.498
Embolization liver	1 (0.4)	0 (0)	1 (0.5)	1.000
Embolization spleen	0 (0)	0 (0)	0 (0)	N/A
Embolization pelvis	4 (1.4)	4 (4.8)	0 (0)	0.007
Thoracotomy or extension of original RT	50 (17.5)	16 (19.3)	34 (16.8)	0.622
Lung resection	3 (1.1)	0 (0)	3 (1.5)	0.559
Cardiac repair	12 (4.2)	1 (1.2)	11 (5.4)	0.190

Megan Brenner, et al. Resuscitative Endovascular Balloon Occlusion of the Aorta and Resuscitative Thoracotomy in Select Patients with Hemorrhagic Shock: Early Results from the American Association for the Surgery of Trauma's Aortic Occlusion in Resuscitation for Trauma and Acute Care Surgery Registry. J Am Coll Surg. 2018 May; 226(5):730-740.

Table 2. Resuscitation Requirements and Laboratory Values among Patients Who Survived Longer than 24 Hours, and Overall Outcomes for all Aortic Occlusion Patients

Variable	Total (N = 285)	REBOA (N = 83)	RT (N = 202)	p Value
Resuscitation requirements, first 24 hours, median (IQR)				
Units packed red blood cells	6.0 (12)	10.0 (21)	7.8 (10)	0.005
Units fresh frozen plasma	4.5 (12)	9.0 (16)	4.0 (9)	0.005
Lab values, first 24 hours				
Lowest hemoglobin, mean ± SD	9.2 (2.5)	9.3 (2.2)	9.1 (2.7)	0.620
Highest INR, median (IQR)	2.1 (1.3)	1.8 (1.2)	2.3 (1.3)	0.669
Lowest base deficit, mean ± SD	16.5 (7.1)	13.8 (7.3)	18.3 (6.3)	0.001
Lowest pH, mean ± SD	6.98 (0.18)	7.04 (0.19)	6.93 (0.16)	0.001
Highest lactate mg/dL, mean ± SD	11.1 (4.7)	10.1 (4.6)	11.8 (4.7)	0.058
Outcomes for all AO patients				
Ventilator days, median (IQR)	1.0 (1)	1.0 (1)	1.0 (1)	0.178
ICU length of stay, d, median (IQR)	0 (1)	0 (1)	0 (1)	0.170
Hospital length of stay, d, median (IQR)	1.0 (0)	1.0 (2)	1.0 (0)	0.075
In-hospital mortality, n (%)	95.4	90.4	97.5	0.023
Discharge GCS among survivors, median (IQR)	3.0 (0)	3.0 (0)	3.0 (0)	0.039

Table 3. Pre-Hospital Demographics: Admission Variables and Intervention Details for Patients Undergoing Zone 1 Aortic Occlusion Prior to CPR in the Emergency Department

Variable	Total (N = 56)	REBOA (N = 27)	RT (N = 29)	p Value
Age, y, mean ± SD	48.3 (20)	52.7 (21.5)	43.9 (17.9)	0.106
Male sex, n (%)	42 (75.0)	20 (74.1)	22 (75.9)	0.877
Penetrating mechanism, n (%)	13 (23.2)	2 (7.4)	11 (37.9)	0.007
Blunt mechanism, n (%)	43 (76.8)	25 (92.6)	18 (62.1)	0.007
ISS, mean ± SD	39.5 (14.7)	41.2 (14.3)	35.8 (15.7)	0.348
Head AIS, mean ± SD	3.3 (1.9)	3.5 (2.0)	3.0 (1.8)	0.572
Chest AIS, median (IQR)	3.1 (1.8)	3.1 (1.7)	3.3 (2.0)	0.735
Field GCS, median (IQR)	3.0 (9)	3.0 (7)	3.0 (11)	0.703
Admission SBP, mmHG, median (IQR)	84 (52)	96 (38)	74 (60)	0.118
Admission GCS, median (IQR)	3.0 (1)	3.0 (6)	3.0 (1)	0.487
Admission hemoglobin, mean ± SD	11.2 (2.4)	11.8 (1.9)	10.1 (2.9)	0.075
Admission hematocrit, mean ± SD	33.3 (7.1)	34.8 (5.8)	30.3 (8.8)	0.124
Admission INR, median (IQR)	1.5 (2.8)	1.3 (1.4)	2.0 (2.7)	0.447
AO initiation physiology				
SBP, mmHg, median (IQR)	40 (66)	64 (29)	0 (0)	<0.001
HR, beats per min, mean ± SD	48 (55)	106 (25)	12 (35)	<0.001
AO physiologic response				
Post-occlusion SBP, mmHg, mean ± SD	75 (63)	120 (34)	34 (54)	<0.001
Duration of AO, min, median (IQR)	39.0 (48)	60.0 (99)	20.0 (21)	0.008
Time from initiation of AO procedures to successful AO, min, median (IQR)	5.0 (8)	3.5 (8)	5.0 (7)	0.624
Adjunctive procedures required, n (%)				
Pelvic binder	9 (16.1)	6 (22.2)	3 (10.3)	0.288
Exploratory laparotomy	28 (50)	21 (77.8)	7 (24.1)	<0.001
Hepatic packing	10 (17.9)	9 (33.3)	1 (3.4)	0.005

Table 6. Resuscitation Requirements and Laboratory Values among Patients Who Survived Longer than 24 Hours, and Overall Outcomes for all Aortic Occlusion Patients Prior to CPR

Variable	Total (N = 56)	REBOA (N = 27)	RT (N = 29)	p Value
Resuscitation requirements, first 24 hours, median (IQR)				
Units packed red blood cells	10.0 (20)	11.5 (22)	6.0 (13)	0.290
Units fresh frozen plasma	10.0 (13)	12.0 (21)	4.0 (14)	0.431
Vasopressors required, n/N (%)	32/47 (68.1)	9/18 (50)	23/29 (79.3)	<0.001
Tranexamic acid, n/N (%)	17/48 (35.4)	8/20 (40.0)	9/28 (32.1)	0.048
Lab values, first 24 hours				
Lowest hemoglobin, mean ± SD	9.6 (2.5)	9.9 (2.5)	8.8 (2.5)	0.225
Highest INR, median (IQR)	1.5 (1.0)	1.5 (0.9)	1.8 (1.7)	0.772
Outcomes for all AO patients				
Ventilator days, median (IQR)	1.0 (3)	1.0 (4)	1.0 (3)	0.291
ICU length of stay, d, median (IQR)	1.0 (5)	1.0 (6)	1.0 (2)	0.200
Hospital length of stay, d, median (IQR)	1.0 (2)	2.0 (8)	1.0 (0)	0.025
In-hospital mortality, n (%)	49 (87.5)	21 (77.8)	28 (96.6)	0.048
Discharge GCS among survivors, median (IQR)	3.0 (0)	9.0 (12)	3.0 (0)	0.026

Megan Brenner, et al. Resuscitative Endovascular Balloon Occlusion of the Aorta and Resuscitative Thoracotomy in Select Patients with Hemorrhagic Shock: Early Results from the American Association for the Surgery of Trauma's Aortic Occlusion in Resuscitation for Trauma and Acute Care Surgery Registry. J Am Coll Surg. 2018 May; 226(5):730-740.

Table 5. Procedure-Specific Complications

Complication	N = 83	
REBOA/endovascular specific complication	n	%
Hematoma	0	0
Pseudoaneurysm	0	0
Arteriovenous fistula	0	0
Extremity ischemia	1	1.2
Stenosis	0	0
Distal embolism	4	4.8
Infection requiring antibiotics only	1	1.2
Need for patch angioplasty	2	2.4
Need for arterial bypass	0	0
Need for amputation	1	1.2
RT complications		
Retained hemothorax requiring operative evacuation via VATS or thoracotomy	3	1.5
Empyema	0	0
Local wound infection requiring surgery	0	0
Endovascular elements of access		
Access site, femoral	83	100
Access side		
Left	17	20.5
Right	62	74.7
Cut-down utilized	39	47.0
Ultrasound guided percutaneous	12	14.5
Percutaneous using external landmark and palpation	23	27.7
Fluoroscopic guided	0	0
Type of balloon catheter utilized		
Coda™	49	59.0
Reliant™	5	6.0
Prytime ER-REBOA™	22	26.5
Other/not otherwise specified	7	8.4
Imaging utilized to facilitate positioning of balloon for AO		
Plain film	47	56.6
C-arm flouroscopy	1	1.2
None, blind insertion using external landmark only	26	31.3
Ultrasound	3	3.6
Successful AO achieved	78	94.0
Balloon migration observed	3	3.6

Conclusions

- 心停止前に大動脈遮断が可能な患者では、蘇生的開胸術より**REBOA**の方が予後を改善する可能性がある

Megan Brenner, et al. Resuscitative Endovascular Balloon Occlusion of the Aorta and Resuscitative Thoracotomy in Select Patients with Hemorrhagic Shock: Early Results from the American Association for the Surgery of Trauma's Aortic Occlusion in Resuscitation for Trauma and Acute Care Surgery Registry. J Am Coll Surg. 2018 May; 226(5):730-740.

REBOA戦略はどうか

Resuscitative endovascular balloon occlusion of the aorta associated with improved survival in hemorrhagic shock

Melike N. Harfouche[1]*, Marta J. Madurska[2], Noha Elansary[1], Hossam Abdou[1], Eric Lang[1], Joseph J. DuBose[3], Rishi Kundi[1], David V. Feliciano[1], Thomas M. Scalea[1], Jonathan J. Morrison[1]

1 R Adams Cowley Shock Trauma Center, University of Maryland Medical System, Baltimore, Maryland, United States of America, 2 The Freeman Hospital, Newcastle upon Tyne, United Kingdom, 3 Dell Medical School, University of Texas at Austin, Austin, Texas, United States of America

Harfouche MN, et al. Resuscitative endovascular balloon occlusion of the aorta associated with improved survival in hemorrhagic shock. PLoS One. 2022;17(3)

- Maryland University, Level 1 trauma center
- Single-center, retrospective, matched cohort study
- 除外：16歳以下、来院時心肺停止
- REBOA　no-REBOAに分けた

- Primary Outcome
  院内死亡
- Secondary Outcomes
  24時間死亡, 30日死亡, 入院日数, 総輸血量, AKI, lower limb complications

Harfouche MN, et al. Resuscitative endovascular balloon occlusion of the aorta associated with improved survival in hemorrhagic shock. PLoS One. 2022;17(3)

Methods

- REBOA groupとno-REBOA groupに分け、

 no-REBOA groupはhistoric group (H:2000-2012)と contemporary (C:2013-2019)に分けた

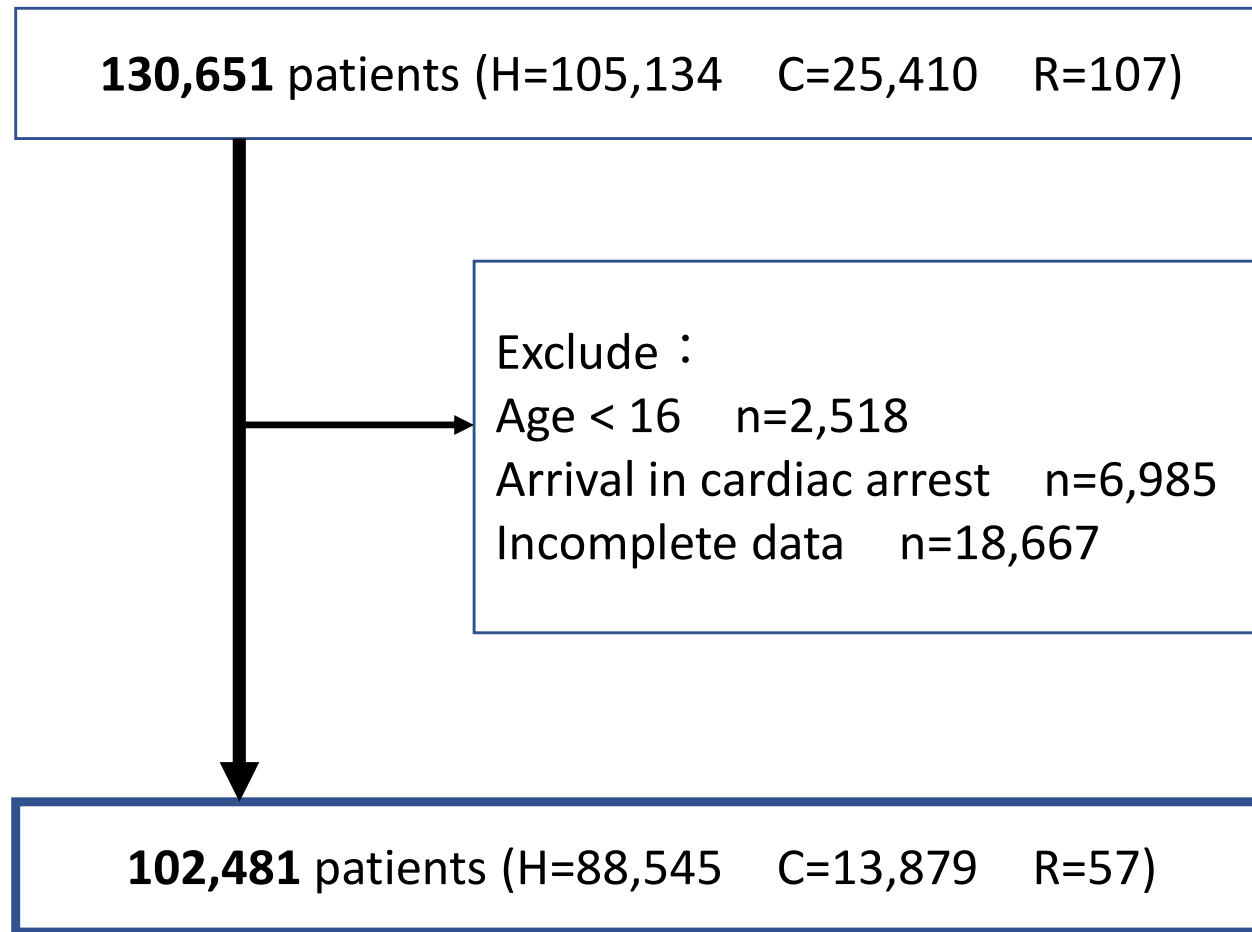- Age, sex, race, mechanism of injury, ISS , SBP, GCS, AISのデータに基づきH group、C groupを設定した

Harfouche MN, et al. Resuscitative endovascular balloon occlusion of the aorta associated with improved survival in hemorrhagic shock. PLoS One. 2022;17(3)

Results

130,651 patients (H=105,134   C=25,410   R=107)

Exclude：
Age < 16   n=2,518
Arrival in cardiac arrest   n=6,985
Incomplete data   n=18,667

102,481 patients (H=88,545   C=13,879   R=57)

Harfouche MN, et al. Resuscitative endovascular balloon occlusion of the aorta associated with improved survival in hemorrhagic shock. PLoS One. 2022;17(3)

Table 1. REBOA to No-REBOA contemporary group before and after propensity-matching*.

	Before Matching			After Matching		
	No-REBOA (n = 13,879)	**REBOA (n = 57)**	**p**	**No-REBOA (n = 114)**	**REBOA (n = 57)**	**p**
Age, y	47 ± 21	37 ± 14	<0.001	42 ± 20	37 ± 14	0.194
Sex n (%)			<0.001			0.050
Male	9326 (66.9%)	51 (89.5%)		83 (72.8%)	51 (89.5%)	
Female	4607 (33.1%)	6 (10.5%)		31 (27.2%)	6 (10.5%)	
Race n (%)			<0.001			0.050
White	4814 (34.5%)	24 (42.1%)		36 (31.6%)	24 (42.1%)	
African-American	7917 (56.8%)	23 (40.4%)		72 (63.2%)	23 (40.4%)	
Other	1205 (8.6%)	10 (17.5%)		6 (5.3%)	10 (17.5%)	
Mechanism n (%)			<0.001			0.764
Blunt	11509 (80.8%)	38 (66.7%)		81 (73%)	38 (66.7%)	
Penetrating	1806 (12.8%)	13 (22.8%)		18 (16.2%)	13 (22.8%)	
Other	564 (6.4%)	6 (10.6%)		12 (10.8%)	6 (10.6%)	
Injury Severity Score	10 ± 10	34 ± 15	<0.001	38 ± 14	34 ± 15	0.420
Lowest SBP, mmHg	113 ± 22	67 ± 18	<0.001	67 ± 21	67 ± 18	0.382
Lowest GCS, mmHg	14 ± 1	5 ± 3	<0.001	4 ± 2	5 ± 3	0.399
Body Region AIS						
Brain	1 ± 1	2 ± 2	0.003	2 ± 2	2 ± 2	0.100
Thorax	1 ± 1	2 ± 1	<0.001	2 ± 1	2 ± 1	0.222
Abdominal	0 ± 1	3 ± 2	<0.001	3 ± 2	3 ± 2	0.600
Upper Extremity	1 ± 1	1 ± 1	<0.001	1 ± 1	1 ± 1	0.709
Lower Extremity	1 ± 1	2 ± 1	<0.001	2 ± 1	2 ± 1	0.587

Table 2. REBOA to No-REBOA historic group before and after propensity-matching*.

|	Before Matching			After Matching		
	No-REBOA (n = 88,545)	**REBOA (n = 57)**	**_p_**	**No-REBOA (n = 114)**	**REBOA (n = 57)**	**_p_**
Age, y	40 ± 19	37 ± 14	<0.001	38 ± 17	37 ± 14	0.969
Sex n (%)			<0.001			0.050
Male	62,161 (70.2%)	51 (89.5%)		80 (70.2%)	51 (89.5%)	
Female	26,367 (29.8%)	6 (10.5%)		33 (28.9%)	6 (10.5%)	
Unknown	17 (0%)	0 (0%)		1 (0.9%)	0 (0%)	
Race n (%)			<0.001			0.313
White	52,352 (59.1%)	24 (42.1%)		31 (27.2%)	24 (42.1%)	
African-American	29,746 (33.6%)	23 (40.4%)		72 (63.2%)	23 (40.4%)	
Other	6,447 (7.3%)	10 (17.5%)		11 (9.6%)	10 (17.5%)	
Mechanism n (%)			<0.001			0.236
Blunt	71,166 (80.4%)	38 (66.7%)		80 (70.2%)	38 (66.7%)	
Penetrating	11,380 (12.9%)	13 (22.8%)		18 (15.8%)	13 (22.8%)	
Unknown	5,999 (6.6%)	6 (10.6%)		16 (14.1%)	6 (10.6%)	
Injury Severity Score	11 ± 10	34 ± 15	<0.001	33 ± 16	34 ± 15	0.553
Lowest SBP, mmHg	127 ± 18	67 ± 18	<0.001	69 ± 21	67 ± 18	0.636
Lowest GCS, mmHg	14 ± 3	5 ± 3	<0.001	4 ± 2	5 ± 3	0.479
Body Region AIS						
Brain	0 ± 0	2 ± 2	<0.001	2 ± 2	2 ± 2	0.589
Thorax	0 ± 0	2 ± 1	<0.001	2 ± 2	2 ± 1	0.178
Abdominal	0 ± 0	3 ± 2	<0.001	3 ± 2	3 ± 2	0.498
Upper Extremity	0 ± 0	1 ± 1	<0.001	1 ± 1	1 ± 1	0.992
Lower Extremity	0 ± 0	2 ± 1	<0.001	2 ± 1	2 ± 1	0.773
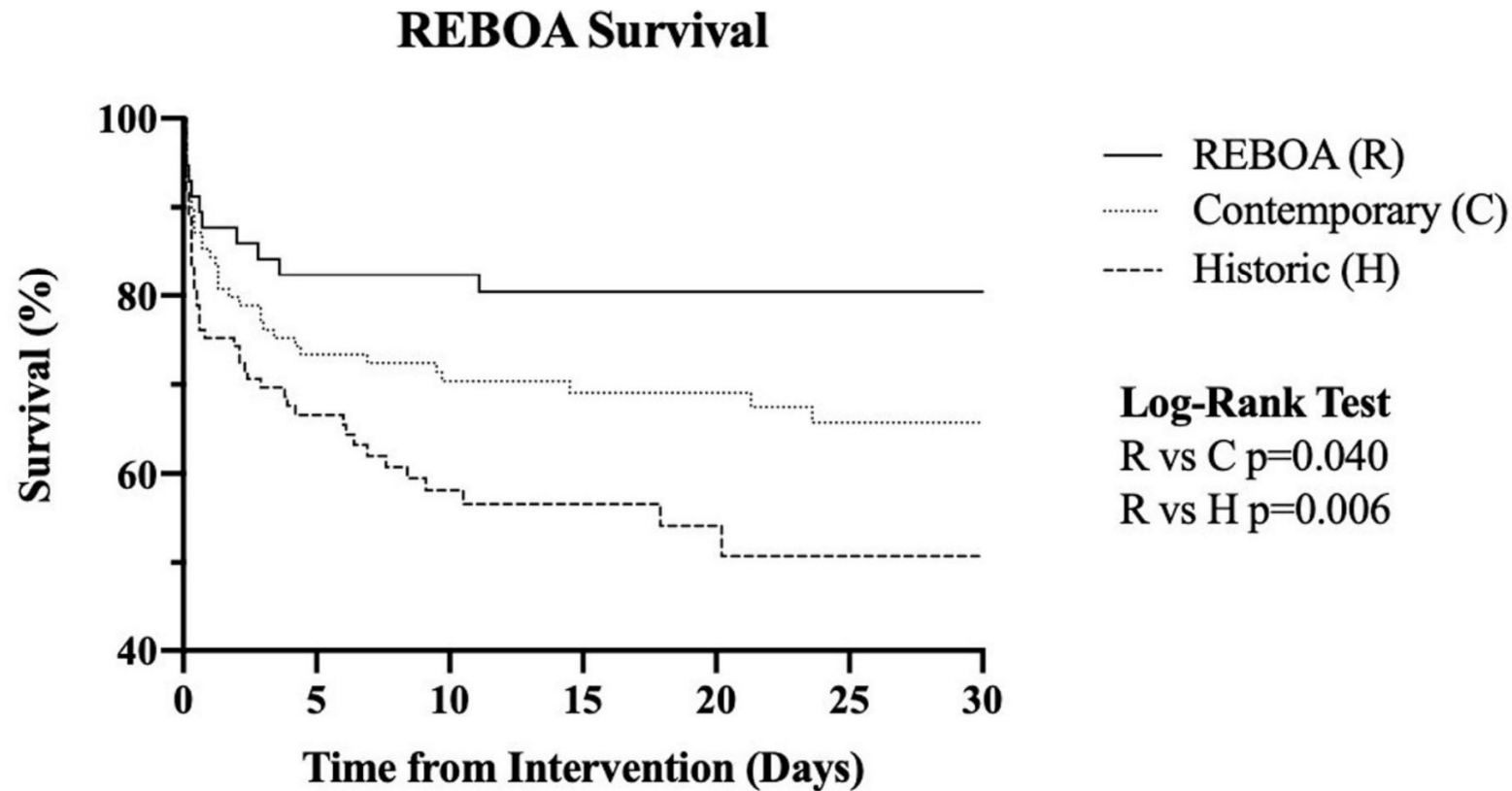
REBOA Survival

Fig 1. Kaplan-Meier estimates of survival over time to 30 days by group (REBOA, contemporary and historic).

死亡原因
- 出血　(R=7, 70%、 C=19, 48.%)
- TBI　　(R=1, 10%、 C=17 43.6%)
- 多因子 (R=2, 20%、 C=3, 7.7%)

Harfouche MN, et al. Resuscitative endovascular balloon occlusion of the aorta associated with improved survival in hemorrhagic shock. PLoS One. 2022;17(3)

Table 3. Primary and secondary outcomes in REBOA and no-REBOA groups (contemporary and historic)[*].

	REBOA	Contemporary	p	Historic	p
24-hour mortality, n(%)	7 (12.3%)	22 (19.3%)	0.175	32 (28.1%)	0.014
In-hospital mortality, n(%)	11 (19.3)	40 (35.1)	0.024	51 (44.7)	0.001
30-day mortality, n(%)	4 (7%)	18 (15.8%)	0.081	19 (16.7%)	0.062
Total length of stay, d[a]	29 ± 29	20 ± 20	0.030	9 ± 9	< 0.001
Total pRBC transfusions	18 ± 18	19 ± 18	0.533	17 ± 14	0.498
Acute Kidney Injury, n(%)	13 (22.8%)	28 (25%)	0.455	27 (23.7%)	0.530

[*] All values reported as median ± interquartile range unless otherwise stated, [a]Includes in-hospital deaths.

REBOA groupで死亡率が低下
輸血投与量は変わらない

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Table 4. Lower extremity complications in REBOA patients by lower extremity AIS score vs No-REBOA patients.

	REBOA	Contemporary	p	Historic	p
Lower Extremity Amputation	3 (5.3%)	1 (0.9%)	0.075	2 (1.8%)	0.203
Lower Extremity Exploration	8 (14.0%)	8 (7.1%)	0.143	8 (7.0%)	0.143
Fasciotomy	4 (7.0%)	3 (2.6%)	0.181	8 (7.1%)	0.976
Thrombectomy	2 (3.5%)	2 (1.8%)	0.445	5 (4.4%)	0.571

下肢の合併症に有意差なし

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＜止血方法＞

- 開腹手術

  R 79% : C 46.5% : H 57%

- 開胸手術

  R 7% : C 14.9% : H 2.6%

- IVR

  R 22.8% : C 14% : H 29.8%

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Conclusion

- **REBOA**使用により死亡率が改善した
- 下肢合併症は変わらなかった

Harfouche MN, et al. Resuscitative endovascular balloon occlusion of the aorta associated with improved survival in hemorrhagic shock. PLoS One. 2022;17(3)

大動脈遮断のタイミング

The critical threshold value of systolic blood pressure for aortic occlusion in trauma patients in profound hemorrhagic shock

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Methods

- Single-center, prospective, observational study
- FundaciónValle del Lili病院（コロンビア）
- Level 1 trauma center
- 2014年1月～2018年12月

＜Include＞
15歳以上で大動脈遮断を受けた外傷患者

＜Exclude＞
病院前心停止

Ordoñez CA, et al. The critical threshold value of systolic blood pressure for aortic occlusion in trauma patients in profound hemorrhagic shock.
J Trauma Acute Care Surg. 2020;89(6):1107-13.

- Primary Outcome

    24-hour mortality

    traumatic cardiac arrest

- Secondary Outcomes

    mortality at 24 hours

    length of ICU stay, hospital stay

    ventilation time

    SOFA score at 2nd day

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Results

TABLE 1. Baseline Characteristics

	Total (n = 107)	No TCA (n = 47)	TCA (n = 60)	p
Male sex, n (%)	94 (88)	39 (83)	55 (92)	0.17
Age, median (IQR)*	31 (23–41)	28 (22–44)	31 (23–40)	0.77
Penetrating trauma, n (%)	89 (83)	35 (74)	54 (90)	0.03
Gunshot wound	68 (76)	27 (77)	41 (76)	0.89
Stab wound	21 (24)	8 (23)	13 (24)	
Blunt trauma, n (%)	18 (17)	12 (25)	6 (10)	0.03
ED-SBP, median (IQR)	60 (20–80)	70 (58–88)	50 (0–76)	<0.001
ED-HR, median (IQR), bpm	108 (45–126)	113 (97–132)	89 (0–120)	0.001
ED-RR, median (IQR), rpm	20 (8–25)	22 (20–26)	14 (0–24)	<0.001
ED-Glasgow, median (IQR)	13 (7–15)	15 (13–15)	8 (3–14)	<0.001
ISS, median (IQR)	25 (25–34)	25 (25–34)	25 (25–33)	0.42
Serious trauma (ISS, 16–24), n (%)	14 (13)	5 (11)	9 (15)	1.0
Severe trauma (≥25), n (%)	88 (82)	40 (85)	48 (80)	0.75
Intraoperative hemorrhage, median (IQR), mL	3,000 (2,000–4,000)	3,000 (2,000–4,000)	3,700 (2,250–4,050)	0.08
Lactate, median (IQR), mmol/L	9.5 (4.6–13.4)	5.4 (3.7–10.8)	13 (10.7–18.0)	0.09
Base excess, median (IQR), mEq/L	−12.3 (−19.6 to −6.0)	−9 (−14.4 to −9.0)	−17.3 (−27.0 to −12.2)	0.001

TABLE 2. Clinical Outcomes

	Total (N = 107)	No TCA (n = 47)	TCA (n = 60)	p
Mortality, first 24 h, n (%)	50 (47)	5 (11)	45 (75)	<0.001
Mortality, total 28 d, n (%)	56 (52)	9 (19)	47 (78)	<0.001
ICU length of stay, median (IQR)	8 (5–19)	8 (5–19)	7 (2–25)	<0.001
Hospital length of stay, median (IQR)	11 (8–26)	11 (8–25)	11 (4–31)	<0.001
Ventilator days, median (IQR)	4 (2–7)	4 (2–7)	5 (2–9)	<0.001
SOFA, day 2, median (IQR)	6 (3–8)	5 (3–8)	8 (5–11)	0.21
MOF, n (%)	27 (25)	19 (40)	8 (13)	0.05

ICU, intensive care unit; MOF, multiple organ failure; SOFA, Sequential Organ Failure Assessment.

TABLE 3. Logistic Regression Model of Mortality at the First 24 Hours

	24-h Mortality		Crude OR		Adjusted OR	
	Yes (n = 50)	No (n = 57)				
	n (%)	n (%)	OR (95% CI)	p	OR (95% CI)	p
Age, median (IQR)	32 (23–43)	28 (22–36)	1.02 (0.99–1.05)	0.140	1.04 (1.00–1.08)	0.042
ISS, median (IQR)	25 (25–34)	25 (25–32)	0.99 (0.96–1.03)	0.820	1.01 (0.96–1.05)	0.653
AO						
REBOA*	11 (22)	39 (68.4)	0.13 (0.05–0.31)	<0.001	0.09 (0.03–0.31)	<0.001
TACC	39 (78)	18 (31.6)				
Trauma mechanism**						
Penetrating	43 (86)	46 (80.7)	1.46 (0.52–4.13)	0.466	0.51 (0.13–2.00)	0.337
Blunt	7 (14)	11 (19.3)				
SBP,† mm Hg						
0	19 (79.1)	5 (20.8)	2.66 (1.25–5.63)	0.001	1.27 (0.53–3.04)	0.05
1–40	5 (55.6)	4 (44.4)	1.19 (0.88–1.86)		0.87 (0.51–1.47)	
41–60	9 (39.3)	14 (60.8)	0.80 (0.52–1.21)		0.72 (0.45–1.15)	
61–80	10 (37)	17 (62.9)	0.54 (0.32–0.88)		0.60 (0.34–1.03)	
81–100	4 (28.5)	10 (71.4)	0.36 (0.18–0.69)		0.49 (0.24–1.00)	
101–120	2 (50)	2 (50)	0.24 (0.10–0.56)		0.41 (0.16–1.02)	
>120	1 (16.6)	5 (83.3)	0.13 (0.04–0.42)		0.37 (0.13–1.04)	

*Aortic occlusion variable was categorized in 1, REBOA, and 0, TACC, for multivariate analysis.

**Trauma mechanism variable was categorized in 1, penetrating trauma, and 0, blunt trauma, for multivariate analysis.

†Systolic blood pressure was calculated as a continuous variable in the multivariate analysis; the estimations for SBP ranges were calculated in the postestimation analysis.
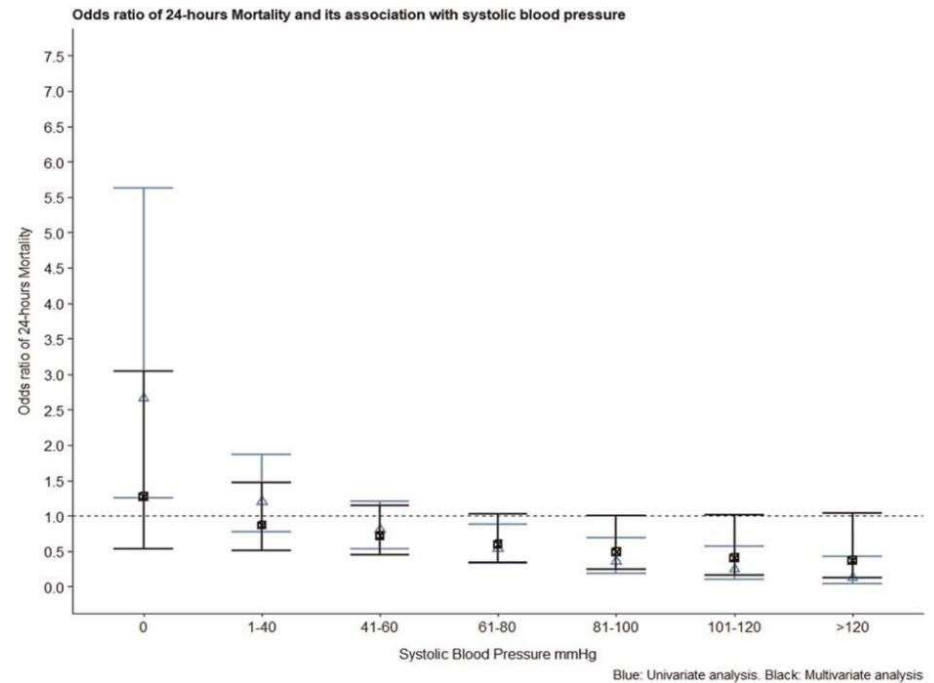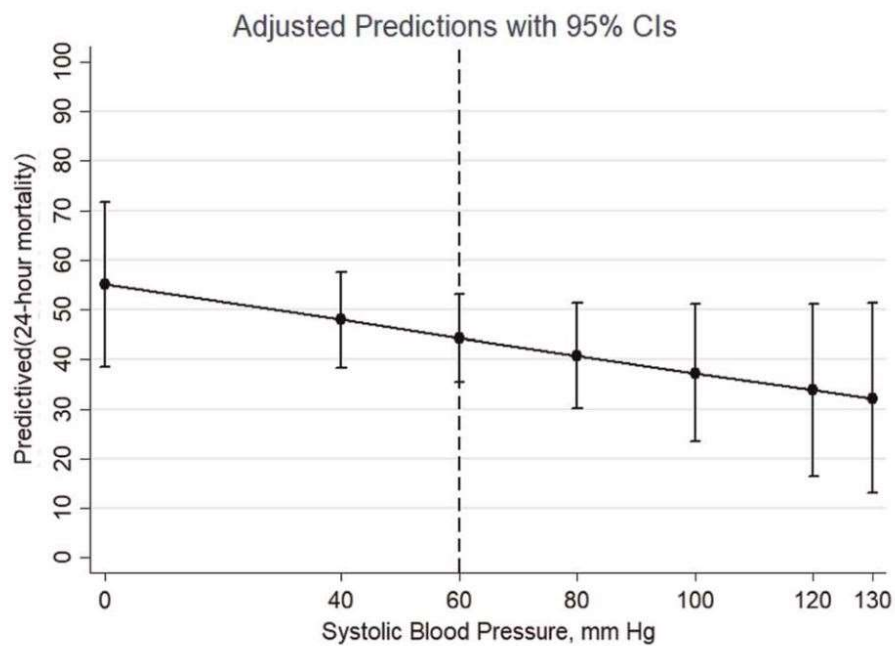
CI, confidence interval.

Ordoñez CA, et al. The critical threshold value of systolic blood pressure for aortic occlusion in trauma patients in profound hemorrhagic shock. J Trauma Acute Care Surg. 2020;89(6):1107-13.

Figure 1. Relationship between SBP upon arrival and 24-hour mortality. *Comparison groups (50 patients who died in the first 24 hours and 57 patients who survived).

Ordoñez CA, et al. The critical threshold value of systolic blood pressure for aortic occlusion in trauma patients in profound hemorrhagic shock. J Trauma Acute Care Surg. 2020;89(6):1107-13.

TABLE 4. Logistic Regression Model for TCA

| | Patients With TCA | | | | | |
| | Yes (n = 60) | No (n = 40) | Crude OR | | Adjusted OR | |
	n (%)	n (%)	OR (95% CI)	p	OR (95% CI)	p
Age, median (IQR)	31 (23–40)	28 (22–44)	1.00 (0.97–1.03)	0.722	1.02 (0.98–1.07)	0.243
ISS, median (IQR)	25 (25–33)	25 (25–34)	0.99 (0.95–1.02)	0.69	1.02 (0.97–1.08)	0.265
AO						
REBOA*	10 (20)	40 (80)	0.035 (0.01–0.1)	<0.001	0.02 (0.01–0.11)	<0.001
TACC	50 (87.7)	7 (12.3)				
Trauma mechanism						
Penetrating**	54 (60.6)	35 (39.3)	3.08 (1.06–8.98)	0.039	0.99 (0.22–4.43)	0.993
Blunt	6 (33.3)	12 (66.6)				
SBP,† mm Hg						
0	24 (100)	0	5.33 (2.23–12.6)	<0.001	3.71 (1.06–12.91)	0.05
1–40	5 (55.5)	4 (44.4)	2.01 (1.22–3.29)		1.93 (0.95–3.91)	
41–50	2 (50)	2 (50)	1.57 (1.01–2.44)		1.64 (0.88–3.04)	
51–60	6 (31.5)	13 (68.4)	1.23 (0.81–1.87)		1.39 (0.79–2.46)	
61–70	5 (50)	5 (50)	0.96 (0.62–1.49)		1.18 (0.67–2.08)	
71–80	8 (47.1)	9 (52.9)	0.75 (0.47–1.22)		1.00 (0.54–1.86)	
81–90	2 (33.3)	4 (66.6)	0.59 (0.34–1.03)		0.85 (0.42–1.72)	
91–100	5 (62.5)	3 (37.5)	0.46 (0.24–0.88)		0.72 (0.32–1.64)	
101–110	2 (66.6)	1 (33.3)	0.36 (0.17–0.76)		0.61 (0.23–1.59)	
>110	1 (14.2)	6 (85.7)	0.13 (0.04–0.45)		0.52 (0.17–1.56)	

*Aortic occlusion variable was categorized in 1, REBOA, and 0, TACC, for multivariate analysis.
**Trauma mechanism variable was categorized in 1, penetrating trauma, and 0, blunt trauma, for multivariate analysis.
†Systolic blood pressure was calculated as a continuous variable in the multivariate analysis; the estimations for SBP ranges were calculated in the postestimation analysis.
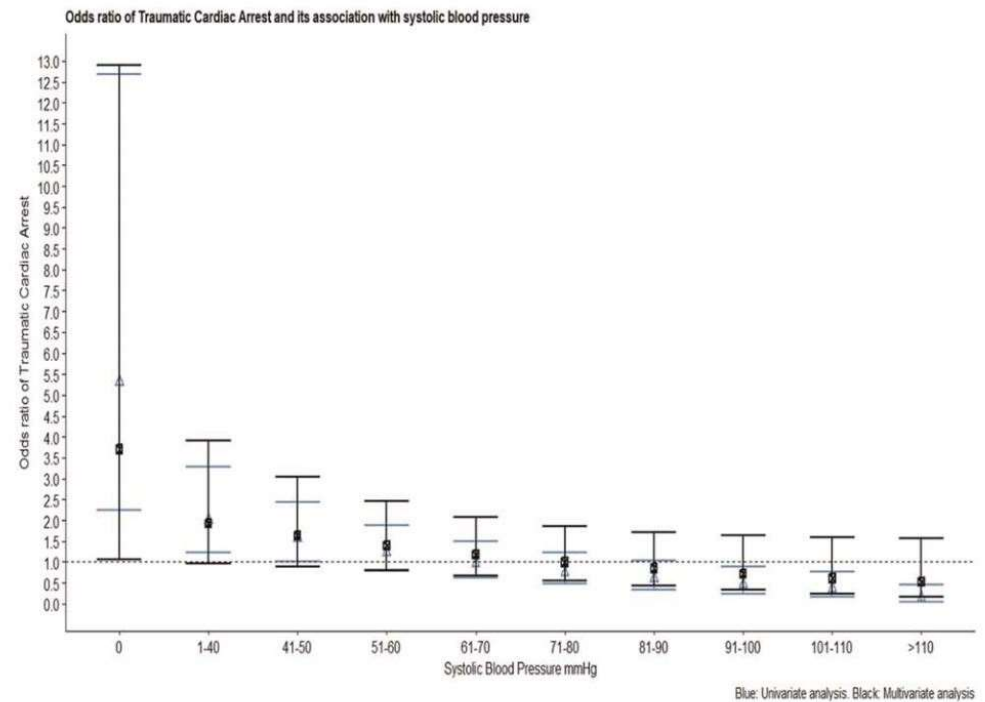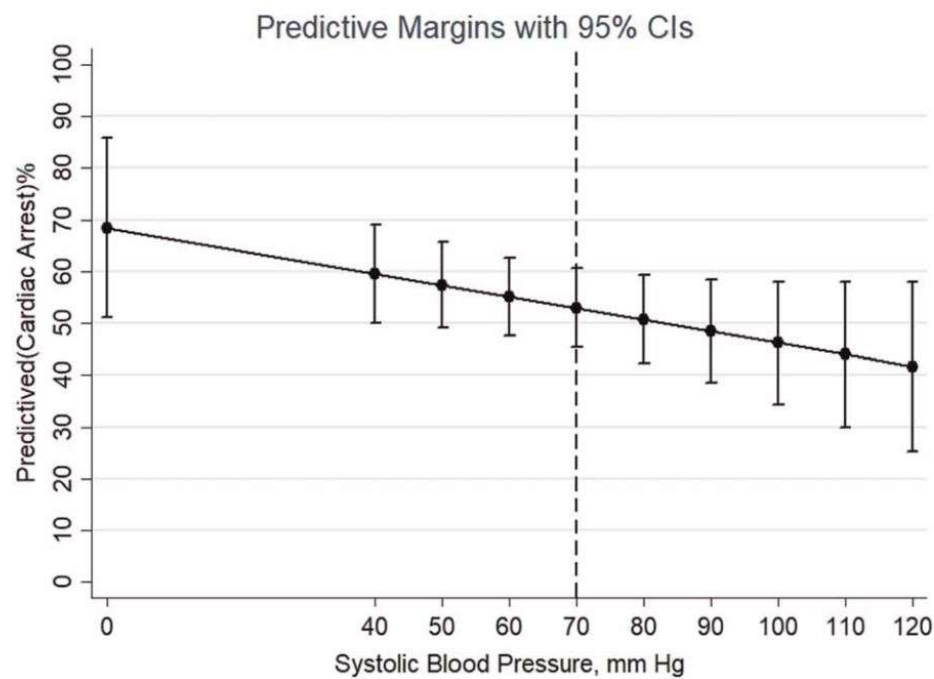CI, confidence interval.

Ordoñez CA, et al. The critical threshold value of systolic blood pressure for aortic occlusion in trauma patients in profound hemorrhagic shock. J Trauma Acute Care Surg. 2020;89(6):1107-13.

Figure 2. Relationship between SBP upon arrival and TCA. *Comparison groups (60 patients with TCA and 40 patients without).

Ordoñez CA, et al. The critical threshold value of systolic blood pressure for aortic occlusion in trauma patients in profound hemorrhagic shock. J Trauma Acute Care Surg. 2020;89(6):1107-13.

Conclusion

- 来院時の血圧70mmHg以下は外傷性心停止に至る可能性が高い
- 来院時血圧60mmHg以下は直ちに大動脈遮断を行うべきである

Ordoñez CA, et al. The critical threshold value of systolic blood pressure for aortic occlusion in trauma patients in profound hemorrhagic shock. J Trauma Acute Care Surg. 2020;89(6):1107-13.

REBOAと動脈アクセス

Time to aortic occlusion: It's all about access

Anna Romagnoli, MD, William Teeter, MD, MS, Jason Pasley, DO, Peter Hu, PhD, Melanie Hoehn, MD, Deborah Stein, MD, MPH, Thomas Scalea, MD, and Megan Brenner, MD, MS, *Baltimore, Maryland*

Methods

- Maryland大学病院
- 単施設、後ろ向き研究
- 2013年2月〜2016年1月
- 常時撮影されているビデオ映像を解析

Anna Romagnoli, et al. Time to aortic occlusion: It's all about access. J Trauma Acute Care Surg. 2017 Dec; 83(6):1161-1164.

Results

TABLE 1. Patients Undergoing RTACC or REBOA

	RTACC	REBOA
Total no. patients	18	21
Age, y	36.9*	39.5
Gender		
Male	16	19
Female	2	2
Body mass index	24.10	26.10
Injury Severity Score	26.33	36.45
Type of injury		
Blunt	1	16
Penetrating	17	5
Mechanism of injury		
Gunshot wound	17	5
Head	0	1
Chest	15	0
Abdomen	1	4
Stab wound	1	0
Chest	1	0
Motor vehicle collision	1	9
Motor car accident	0	3
Pedestrian struck	0	2
Fall	0	2

*Group contains one John Doe of unknown age.

Anna Romagnoli, et al. Time to aortic occlusion: It's all about access. J Trauma Acute Care Surg. 2017 Dec; 83(6):1161-1164.

TABLE 2. Comparison of Group 1 (Cardiac Arrest) Versus
Group 2 (Hypotensive) REBOA Patients

All Times in Seconds (Q1, Q3)	Group 1 (n = 14)	Group 2 (n = 7)	p
Median time to aortic occlusion*	466.5 (429, 603)	488 (451, 541)	0.97
Median time to arterial access**	191.5 (132, 240)	84 (55, 132)	0.03
CFA access (percutaneous), %	0.14	0.87	

*Start of procedure defined as start of first CFA access attempt.
**Start of procedure defined as first CFA access attempt to placement of arterial line or micropuncture cannula.

心停止例では動脈アクセスに時間を要した
心停止例ではカットダウンを要することが多かった

Anna Romagnoli, et al. Time to aortic occlusion: It's all about access. J Trauma Acute Care Surg. 2017 Dec; 83(6):1161-1164.

TABLE 3. Comparison of RTACC and REBOA Procedures

All Values in Seconds (Q1, Q3)	RTACC (n = 18)	REBOA (n = 21)	p
Median time to aortic occlusion*	317.5 (227, 551)	474 (431, 572)	0.01
Median time to aortic occlusion once CFA access was established		245 (179, 295.5)	0.003

*Start of procedure defined as start of first CFA access attempt for REBOA and skin incision for RTACC.

動脈アクセスがある場合にはREBOAの方が迅速に
大動脈遮断が可能であった

Anna Romagnoli, et al. Time to aortic occlusion: It's all about access. J Trauma Acute Care Surg. 2017 Dec; 83(6):1161-1164.

Conclusions

- **REBOA**活用には動脈アクセスが重要

- **REBOA**システムの改良により、現在では**REBOA**による大動脈遮断までの時間は更に短縮されている。
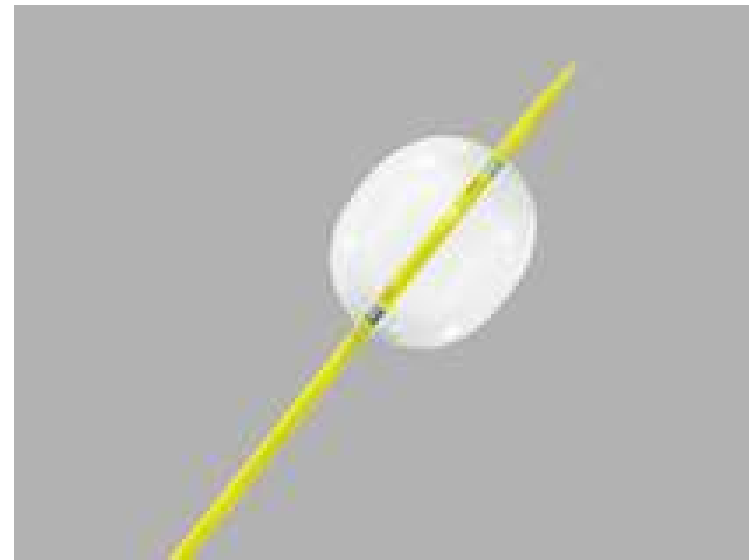
Coda$^®$ Balloon Catheter(12Fr); COOK Medical

Anna Romagnoli, et al. Time to aortic occlusion: It's all about access. J Trauma Acute Care Surg. 2017 Dec; 83(6):1161-1164.

Take Home Message

- **REBOA**はまだエビデンスが定まっていないが、習熟すれば低侵襲で迅速に大動脈遮断が可能であり、横隔膜以下の出血コントロールの戦略の１つとして有効である可能性がある

- **REBOA**の使用が予想される状態においては早期に動脈アクセスを確保しておくことが重要である