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ORIGINAL ARTICLE

Finding the systolic blood pressure threshold value for endovascular aortic occlusion: global analysis of REBOA databases

Buscando el punto crítico de presión arterial sistólica para la oclusión endovascular de la aorta: Análisis mundial de los registros REBOA

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Abstract

Introduction. Systolic blood pressure (SBP) can be a determining factor for decision-making in the management of patients with severe trauma and non-compressible torso bleeding (NTCH). The objective of this study was to determine the optimal SBP threshold value prior to endovascular occlusion of the aorta associated with 24-hour mortality.

Methods. A combined analysis of two REBOA registry databases, ABO-Trauma Registry and AAST-AORTA, was performed, which includes patients from North America, South America, Europe, Asia, and Africa. Patients without hemodynamic effect with the use of REBOA were excluded. Demographic, clinical, and REBOA placement characteristics were described in patients who died in the first 24 hours. The association between SBP prior to aortic occlusion and mortality was analyzed using logistic regression models and the predictive power of SBP was evaluated in an interval between 60 and 90 mmHg.

Results. 871 records were identified, but only 693 patients met the inclusion criteria. Blunt trauma occurred in 67.2% of the patients and the severity of the trauma had a median ISS of 34 (IQR: 25-45). The median systolic blood pressure prior to REBOA was 61 mmHg (IQR: 46-80). The 24-hour mortality was 34.6%. The association between systolic blood pressure pre-occlusion of the aorta and mortality at 24 hours has a predictive capacity according

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to the area under the ROC curve for blunt trauma of 0.64 (95% CI: 0.59-0.70) and for penetrating trauma of 0.61 (95% CI: 0.53-0.69). A systolic blood pressure of 70 mmHg was found to be associated with an increase of over 25% in mortality at 24 hours.

Discussion. SBP of 70 mmHg in patients with severe trauma and non-compressible hemorrhage may be the critical point for endovascular aortic occlusion to improve patient survival, regardless of the mechanism of trauma. However, systolic blood pressure must be supplemented with other clinical factors to make the timely decision.

Keywords: aorta; endovascular procedures; balloon occlusion; wounds and injuries; hemorrhage; blood pressure; mortality; REBOA.

Resumen

Introducción. La presión arterial sistólica puede ser un factor determinante para la toma de decisiones en el manejo de pacientes con trauma severo y hemorragia no compresible del torso. El objetivo de este trabajo fue determinar el punto óptimo de presión arterial sistólica previo a la oclusión endovascular de aorta asociado con la mortalidad a 24 horas.

Métodos. Se realizo un análisis combinado de dos bases de datos de registro de REBOA, *ABO-Trauma Registry* y *AAST-AORTA*, que incluye pacientes de Norte América, Suramérica, Europa, Asia y África. Pacientes sin efecto hemodinámico con el uso del REBOA fueron excluidos. Se describieron las características demográficas, clínicas y de la colocación del REBOA en los pacientes que fallecieron en las primeras 24 horas. Se analizó la asociación entre la presión arterial sistólica previa a la oclusión aortica y la mortalidad a través de modelos de regresión logística y se evaluó el poder predictivo de la PAS en un intervalo entre 60 y 90 mmHg.

Resultados. Fueron identificados 871 registros, pero solo 693 pacientes cumplieron con los criterios de inclusión. El trauma cerrado se presentó en el 67,2 % de los pacientes y la severidad del trauma tuvo una mediana de ISS de 34 (RIQ: 25-45). La mediana de la presión arterial sistólica previa al REBOA fue de 61 mmHg (RIQ: 46-80). La mortalidad a 24 horas fue del 34.6%. La asociación entre la presión arterial sistólica pre-oclusión de la aorta y la mortalidad a 24 horas tiene una capacidad predictiva de acuerdo con el área bajo la curva ROC para trauma cerrado de 0,64 ($IC_{95\%}$ 0,59-0,70) y para trauma penetrante de 0,61 ($IC_{95\%}$ 0,53-0,69). Se identificó que la presión arterial sistólica de 70 mmHg se asocia con un aumento por encima del 25 % de la mortalidad a 24 horas.

Discusión. La presión arterial sistólica de 70 mmHg en pacientes con trauma severo y hemorragia no compresible puede ser el punto crítico para la oclusión endovascular de aorta para mejorar la supervivencia de los pacientes, sin importar el mecanismo de trauma. Sin embargo, la presión arterial sistólica debe complementarse con otros factores clínicos para tomar la decisión oportuna.

Palabras clave: aorta; procedimientos endovasculares; oclusión con balón; heridas y lesiones; hemorragia; presión sanguínea; mortalidad; REBOA.

Introduction

Massive bleeding is the leading preventable cause of death in patients with trauma and noncompressible bleeding from the torso, causing 60% to 70% of deaths [1,2]. Rapid control of bleeding is essential in these situations, and delay in interventions is associated with increased mortality [3,4].

Aortic occlusion is a temporary measure to control the rate of exsanguination and increase cerebral and coronary perfusion [5]. Classically, this procedure has been used in patients *in extremis* through the thoracic or abdominal approach, but recently, it has been achieved through an endovascular balloon called REBOA (Resuscitative Endovascular Balloon Occlusion of the Aorta), allowing less invasive access, possibility of earlier interventions and having an active and dynamic tool in resuscitation efforts [6,7].

It is currently a challenge to define when to intervene with the use of REBOA in patients with trauma and severe hemorrhagic shock to increase their survival. The indications for aortic occlusion are prehospital cardiac arrest, with cardiopulmonary resuscitation maneuvers not exceeding 15 minutes for penetrating thoracic trauma and 10 minutes for blunt trauma. However, these indications apply to patients with hemodynamic collapse, in whom occlusion of the aorta is considered the last rescue measure [8].

REBOA allows for earlier intervention and temporary control of the injury to avoid cardiac arrest [9,10]. To identify possible hemodynamic instability in patients with massive bleeding, systolic blood pressure (SBP) has been postulated as a clinical parameter. The American College of Surgeons has proposed having a SBP <90 mmHg as a reference in the initial evaluation for decision-making [11]. However, in deciding whether to perform aortic occlusion or other aggressive measures in resuscitation, this value can be controversial [9,12,13]. It has been postulated that identifying a SBP value for aortic occlusion could be associated with an increase in survival.

Previously, the authors, with their local experience in the use of REBOA, although with the limitation of being the experience of a single center, have explored this hypothesis, finding that a SBP of less than 60 mmHg at the time of admission is associated with mortality at 24 hours greater than 50% [14,15]. The objective of this study was to determine the optimal point of SBP prior to occlusion of the aorta using REBOA in patients with severe trauma and non-compressible bleeding from the torso.

Methods

Study design

A combined analysis of two prospectively collected databases was made regarding the management of REBOA.

The ABO-Trauma registry is an international, multicenter, observational, prospective database, funded by the Department of Cardiothoracic and Vascular Surgery of the University Hospital of Örebro (Örebro, Sweden) and the Endovascular and Trauma Management (EVTM) research group. This registry includes hospitals in Russia, Israel, Sweden, Finland, Japan, Italy, South Korea, Thailand, South Africa, Germany, Colombia, Turkey, and the Netherlands. The records collected between July 2014 and December 2019 were included.

The Aortic Occlusion for Resuscitation in Trauma and Acute Care Surgery (AORTA) registry, developed by the American Association for the Surgery of Trauma (AAST), is a prospective, observational, multicenter registry that evaluates the use of aortic occlusion in the resuscitation of haemodynamically unstable patients with severe trauma. Subjects from the AAST-AORTA database were collected between November 2013 and January 2020, and only patients who underwent aortic occlusion through the placement of the REBOA were included.

Similar variables from the two databases were combined into a single database for analysis, similar to previous work by Duchesne et al [10]. Additionally, information on resuscitation requirements, such as volume of crystalloids and blood products transfused in the first 24 hours, from the AAST-AORTA database was included. Those patients with a SBP of 0 mmHg prior to aortic occlusion and who remained that way after occlusion were excluded.

Variables

The demographic and clinical information collected was: age, gender, mechanism of trauma, severity of trauma by Injury Severity Score (ISS), anatomical location of the injury, prehospital cardiac arrest, vital and paraclinical signs at admission, technical details in the placement of the REBOA, zone of aortic occlusion, time of aortic occlusion, SBP before and after REBOA insertion, 24-hour mortality and in-hospital mortality.

Polytrauma was defined as two or more injured anatomical regions. The SBP delta was defined as the difference between the SBP after insertion and the SBP before insertion. The hemodynamic non-response was considered as that patient with SBP prior to insertion greater than SBP after insertion of the REBOA.

Statistical analysis

The categorical variables were reported as absolute frequency and relative frequency. Continuous variables were described using median and interquartile range (IQR). For categorical variables, their differences were evaluated using the Chi-square test or Fisher's exact test. Continuous variables were compared using the U-Mann-Whitney test. Patients with 24-hour mortality and survivors were compared.

To determine the relationship between SBP prior to aortic occlusion and mortality at 24 hours, univariate logistic regression models were explored, according to the mechanism of trauma and a linear, quadratic or cubic data relationship. The evaluation of the model was analyzed using the Hosmer-Lemeshow Chi-square test and the Bayesian Criterion Information (BIC) was used to choose the best model according to the parsimony principle. The clinically relevant cut-off point was defined as that point of SBP associated with an estimated 24-hour mortality value greater than 25%.

To evaluate the discriminatory capacity of the SBP threshold in predicting mortality at 24 hours, an analysis of ROC curves (Receiver Operating Characteristics) was performed and the Area Under the Curve (AUC) was calculated. The best cut-off point for SBP, with respect to sensitivity and specificity, was estimated using the Youden index [16]. However, estimates were found below 60 mmHg, which could have little applicability in the clinical context, for which the cut-off points of SBP in the range of 60 to 90 mmHg, per 10 mmHg, were evaluated through sensitivity, specificity, predictive values, likelihood ratio and odds ratio. 95% confidence intervals (95% CI) were calculated. Statistical analysis was performed using R-Language version 3.6.3 [17].

Results

General characteristics

A total of 871 records were obtained from the databases, 184 records from the ABO-Trauma registry and 687 records from the AAST-AORTA. 178 patients were excluded because they presented incomplete information on SBP before or after REBOA placement, or because SBP remained at 0 mmHg despite REBOA placement. 693 patients were included in the analysis, whose general characteristics were: 517 (74.6%) were men, with a median age of 42 years (IQR: 27-58), the most common trauma mechanism was blunt reported in 466 (67.2%) patients, and the median ISS was 34 (IQR: 25-45).

Mortality at 24 hours occurred in 240 (34.6%) patients. The characteristics of patients who died in the first 24 hours versus survivors are summarized in Tables 1 and 2. The proportion of patients with prehospital cardiac arrest was higher in the group with mortality after 24 hours (91, 37.9%) than among survivors (57, 12.6%), with a statistically significant difference (p <0.001). As can be seen in Table 1, the clinical and paraclinical parameters of the patients who died in the first 24 hours were more severely altered. In-hospital mortality in the group of patients surviving at 24 hours was reported in 136 (30%) patients

Regarding the technical criteria for REBOA placement, among patients with access through the femoral artery, the procedure was performed in the emergency department in 474 (68.3%) patients and the most common technique was percutaneous, in 326 (47%) patients. The most common area of occlusion of the aorta was zone 1 (471, 67.9%). Median SBP prior to REBOA insertion was higher in the survivors group (67, IQR: 50-81 mmHg) than in the 24-hour mortality group (53, IQR: 0-72 mmHg), with a statistically significant difference (p <0.001). Additionally, 70 (29.2%) of the patients who died in 24 hours did not have a positive hemodynamic response with the placement of the REBOA. The median duration of aortic occlusion was 41 minutes (IQR: 24-65).

Association between SBP prior to REBOA and mortality at 24 hours

With the distribution of the data, according to the logistic regression models of the SBP prior to the insertion of the REBOA and the mortality at 24 hours, it was identified that the best model for

Table 1. General characteristics of the study population.

	Total (n=693)	Survivor (n=453)	Mortality at 24 hours (n=240)	p
Age, median (IQR)	42 (27-58)	42 (27.58)	42 (27-59)	0.7
Male, n (%)	517 (74.6)	340 (75.1)	177 (73.8)	0.776
Mechanism of trauma, n (%)				
Blunt	466 (67.2)	298 (65.8)	168 (70)	
Penetrating	223 (32.1)	151 (33.3)	72 (30)	0.214
Combined	4 (0.5)	4 (0.9)	0	
Injury Severity Score, median (IQR)	34 (25-45)	34 (25-43)	35 (25-50)	0.051
Anatomical location of trauma, n (%)				
Cranioencephalic	280 (40.4)	173 (38.2)	107 (44.6)	0.121
Thorax	312 (45.0)	191 (42.2)	121 (50.4)	0.045
Abdomen	439 (63.3)	295 (65.1)	144 (60)	0.211
Pelvis	162 (23.3)	119 (26.3)	43 (17.9)	0.017
Polytrauma	392 (56.5)	255 (56.3)	137 (57.1)	0.904
Prehospital cardiac arrest, n (%)	148 (21.3)	57 (12.6)	91 (37.9)	<0.001
Lack of pupillary response, n (%)	296 (42.7)	143 (31.6)	153 (63.7)	<0.001
SBP on admission, mmHg, median (IQR)	70 (10-102)	81 (70-110)	70 (0-95)	<0.001
Heart rate on admission, beats per minute, n (%)				
<50	67 (9.6)	17 (3.8)	50 (20.8)	
50-100	142 (20.4)	96 (21.2)	46 (19.2)	<0.001
101-120	146 (21.1)	100 (22.1)	46 (19.2)	
>120	295 (42.5)	216 (47.7)	79 (32.9)	
pH on admission, median (RIQ)	7.18 (7.03-7.27)	7,22 (7.12-7.29)	7.04 (6.93-7.16)	<0.001
Lactate on admission, mg/dl, median (IQR)	6.7 (4.1-10.9)	5,6 (3.7-8.7)	10.4 (6.7-13.6)	<0.001
Hemoglobin on admission, mg/dl, median (RIQ)	10.9 (8.4-12.4)	11,4 (9.7-12.8)	10,4 (8.4-12)	<0.001
INR on admission, median (IQR)	1.4 (1.2-1.7)	1,3 (1.17-1.51)	1.7 (1.4-2.4)	<0.001
Mortality, n (%)				
Mortality at 24 hours	240 (34.6)	-	-	NA
Intrahospital	375 (54.1)	136 (30,0)	-	
Place of Death, n (%)				
Emergency room	90 (24)	11 (8.1)	79 (33.1)	
Operating room	74 (19.7)	5 (3.6)	69 (28.5)	
Intensive Care Unit	207 (55.2)	119 (87.5)	89 (37.1)	<0.001
Interventional radiology	2 (0.5)	0	2 (0.8)	

* IQR: Interquartile range; SBP: systolic blood pressure; INR: international normalized ratio.

patients with blunt trauma has a quadratic relationship, while for penetrating trauma patients have a linear relationship (Table 3).

Regarding blunt trauma, the distribution of mortality has an approximate rise for SBP values prior to REBOA below 70 mmHg and above 100 mmHg. The SBP prior to REBOA insertion in which mortality was greater than 25% in patients with blunt trauma was 84 mmHg (estimated probability 25.1%, 95% CI 20.2-30.3), and in patients with penetrating trauma was 85 mmHg (estimated probability 25.4%, 95% CI 18-32.8).

Regarding the practical SBP values, the associated probability in the model was estimated for the cut-off points of 60 and 70 mmHg. The SBP of 60 mmHg prior to REBOA placement was associated with a mortality of 28.1% (95% CI 23.1-33.2) in blunt trauma and 32% (95% CI 25.6-38.4) in

Table 2. Characteristics related to REBOA placement and resuscitation requirements.

	Total (n=693)	Survivor (n=453)	Mortality at 24 hours (n=240)	p
Femoral access site, n (%)				
Emergency room	474 (68.3)	290 (64)	184 (76.7)	0.005
Operating room	183 (26.4)	136 (30)	47 (19.6)	
Interventional Radiology	17 (2.4)	12 (2.6)	5 (2.1)	
No Data	19 (2.7)	15 (3.3)	4 (1.7)	
Arterial Access Method, n (%)				
Percutaneous	326 (47.0)	224 (49.4)	102 (42.5)	<0.001
Guided by ultrasound	208 (30.0)	149 (32.6)	59 (24.6)	
Fluoroscopy	11 (1.5)	9 (2.0)	2 (0.8)	
Open technique	128 (18.4)	55 (12.6)	73 (30.4)	
No Data	20 (2.8)	16 (3.5)	4 (1.7)	
Aortic Occlusion Zone, n (%)				
1	471 (67.9)	277 (61.1)	194 (80.8)	<0.001
2	14 (2.0)	11 (2.4)	3 (1.2)	
3	208 (30.0)	165 (36.4)	43 (17.9)	
Staff in charge of REBOA, n (%)				
Trauma Surgeon	482 (69.5)	316 (69.8)	166 (69.2)	0.1
Trauma Fellow	55 (7.9)	34 (7.5)	21 (8.8)	
General Surgery Resident	9 (1.2)	5 (1.1)	4 (1.7)	
Vascular Surgeon	32 (4.6)	26 (5.7)	6 (2.5)	
Radiologist	23 (3.3)	15 (3.3)	8 (3.3)	
Emergency Medicine	59 (8.5)	9 (2.0)	2 (0.8)	
SBP prior to insertion, mmHg, median (IQR)	61 (46-80)	67 (50-81)	53 (0-72)	<0.001
PAS post insertion, mmHg, median (IQR)	104 (87-125)	108 (92-125)	95 (50-122)	<0.001
Non-hemodynamic response, n (%)	111 (16.0)	41 (9.1)	70 (29.2)	<0.001
SBP Delta, median (IQR)	36 (15-61)	36 (20-60)	36 (0-66)	0.064
Aortic occlusion time, minutes, median (IQR)	41 (24-65)	40 (25-64)	45 (23-67)	0.407
Resuscitation requirements				
Total crystalloids, Liters, median (IQR)	3 (2-6)	4 (2-6)	2 (1-4)	<0.001
Units of packed red blood cells, median (IQR)	13 (7-23)	12 (7-22)	14 (5-24)	0.818
Platelet Units, median (IQR)	3 (1-7.5)	2 (1-6)	2 (0-5)	0.151
Fresh frozen plasma units, median (IQR)	9 (4-13)	7 (4-13)	9 (3-16)	0.396

* IQR: Interquartile range; SBP: Systolic blood pressure.

Table 3. Evaluation of the logistic regression models of systolic blood pressure prior to REBOA insertion and mortality at 24 hours in trauma patients.

Mechanism of trauma	Type of logistic regression model	Bonda test (Chi square - p-value)	BIC
Blunt trauma	Lineal	23.7 – 0.003	593.1
	Quadratic	7.02 – 0.531	577.9
	Cubic	6.62 – 0.577	582.9
Penetrating trauma	Lineal	2.50 – 0.961	282.7
	Quadratic	7.56 – 0.476	284.6
	Cubic	8.17 – 0.416	289.9

*BIC: Bayesian Criterion Information

penetrating trauma. In contrast, a SBP of 70 mmHg was associated with a mortality of 26.1% (95% CI 21.3-31.0) for blunt trauma and 29.2% (95% CI 22.7-35.8) for trauma penetrating (Figure 1).

Prognostic performance of SBP cut-off points prior to REBOA

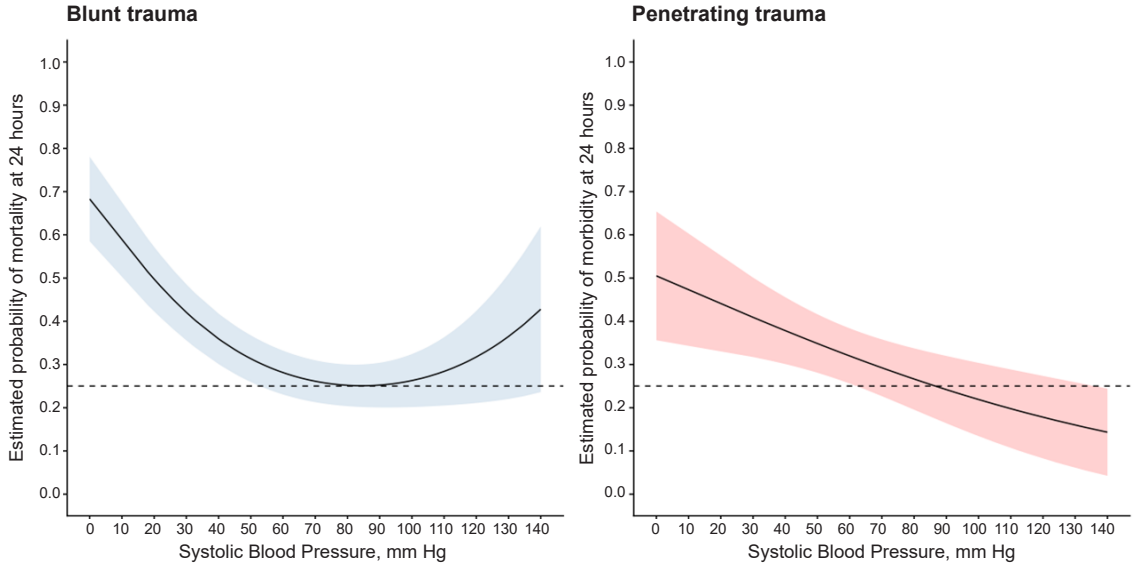
The ROC curves according to the trauma mechanisms are shown in Figure 2. The area under the SBP curve for mortality in 24 hours in blunt trauma was 0.646 (95% CI 0.591-0.701) and in penetrating trauma it was 0.618 (95% CI 0.537-0.699). The cut-off point according to Youden's index was 41 mmHg for blunt trauma and 47 mmHg for penetrating trauma. However, in order to describe a cut-off point with clinical applicability, it was evaluated in a SBP range between 60 and 90 mmHg per 10 mmHg. Table 4 summarizes the sensitivity, specificity, predictive values, likelihood ratios, and odds ratios with each cut-off point.

The SBP prior to REBOA of 70 mmHg is related to an increase in mortality greater than 25%, both in blunt trauma and in penetrating trauma. This value in blunt trauma had a specificity of 42% (95% CI 36-47%), a positive predictive value of 42% (95% CI 36-47%), with an OR of 2.00 (95% CI 1, 30-3.11). On the other hand, for penetrating trauma it had a specificity of 38% (95% CI 31-47), with a positive predictive value of 36% (95% CI 29-45) and an OR of 1.73 (95% CI 0.90-3.42).

Discussion

The management of patients with non-compressible hemorrhage from the exsanguinating torso is a challenge since defining who can benefit from aortic occlusion is still uncertain with the current scientific evidence. The SBP has been used as a classic parameter to determine the need for occlusion of the aorta since it is a quick and simple variable to measure. However, the estimation of a critical point of SBP prior to aortic occlusion that indicates to the clinician about the mortality possibilities of patients is currently a topic under investigation [9,10,14].

This study compiles information from several medical centers in North America, South America, Europe, Asia, and Africa, which have ventured into the use of REBOA for the management of patients



Solid line corresponds to the estimated 24-hour mortality and the shaded areas represent the 95% confidence interval. The dotted line represents the 25% mortality point. The data distribution of patients with blunt trauma has a quadratic relationship and a Bondad test of p=0.531, while in patients with penetrating trauma it has a linear relationship and a Bondad test of p=0.961.

Figure 1. Mortality at 24 hours according to SBP prior to aortic occlusion by REBOA.

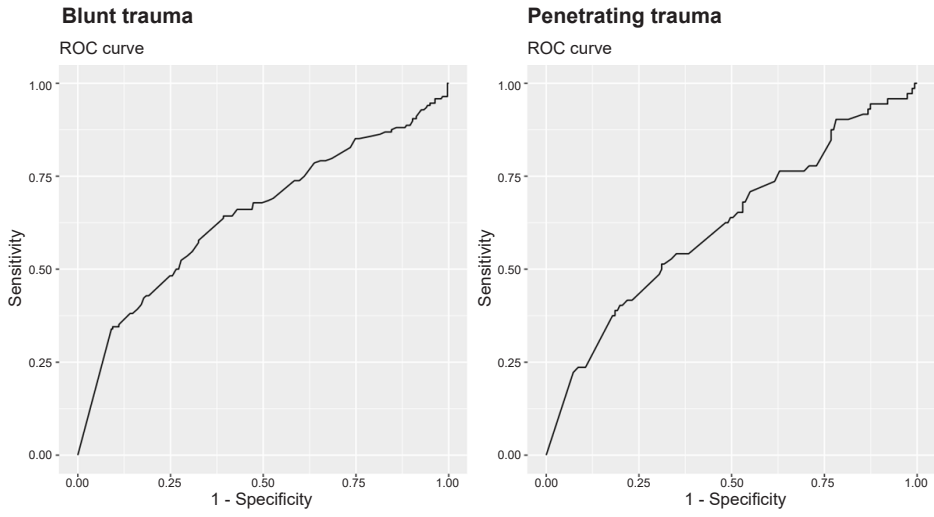


Figure 2. ROC curves of systolic blood pressure prior to occlusion of the aorta with REBOA for mortality at 24 hours.

Table 4. Summary of cut-off points for systolic blood pressure (SBP) prior to REBOA to predict mortality in 24 hours.

Mechanism of Trauma	SBP prior to REBOA	Sensitivity	Specificity	PPV	NPV	LR+	LR-	OR (95% CI)
Blunt trauma	<60 mm Hg	64 (56-71)	61 (55-66)	48 (41-55)	75 (69-80)	1.62 (1.35-1.95)	0.60 (0.48-0.74)	2.71 (1.80-4.09)
	< 70 mm Hg	74 (66-80)	42 (36-47)	42 (36-47)	74 (66-80)	1.26 (1.11-1.44)	0.63 (0.47-0.84)	2.00 (1.30-3.11)
	< 80 mm Hg	83 (76-88)	27 (22-32)	39 (34-44)	73 (64-81)	1.13 (1.02-1.24)	0.65 (0.44-0.95)	1.72 (1.05-2.88)
	< 90 mm Hg	88 (82-93)	14 (10-19)	37 (32-42)	68 (55-79)	1.03 (0.95-1.10)	0.84 (0.51-1.39)	1.21 (0.66-2.26)
Penetrating trauma	<60 mm Hg	62 (50-74)	52 (43-60)	38 (29-48)	74 (65-82)	1.29 (1.01-1.65)	0.73 (0.52-1.02)	1.78 (0.96-3.30)
	< 70 mm Hg	74 (62-83)	38 (31-47)	36 (29-45)	75 (64-84)	1.20 (0.99-1.44)	0.69 (0.44-1.06)	1.73 (0.90-3.42)
	< 80 mm Hg	85 (74-92)	23 (17-31)	34 (27-42)	76 (61-87)	1.10 (0.97-1.26)	0.66 (0.36-1.22)	1.67 (0.76-3.90)
	< 90 mm Hg	92 (83-97)	15 (9-21)	34 (27-41)	79 (59-92)	1.07 (0.97-1.18)	0.57 (0.24-1.35)	1.87 (0.69-5.91)

SBP: systolic blood pressure; PPV: Positive predictive value; NPV: negative predictive value; LR: Likelihood ratio; OR: Odds ratio; CI: Confidence interval

with severe trauma. This is one of the studies with the largest sample size, which made it possible to determine that the points with the best statistical performance to predict mortality at 24 hours were a SBP of 41 mmHg in blunt trauma and a SBP of 47 mmHg for penetrating trauma.

However, these values have no clinical applicability because they are values with a high risk of mortality and cardiac arrest [9]. Therefore, the univariate association between 24-hour mortality and SBP prior to REBOA was explored, finding a quadratic relationship of these variables in blunt trauma and a linear relationship in penetrating trauma. These findings are consistent with estimates of the risk of SBP on admission in critically ill or severe trauma patients [18–20]. It should be noted that the age, the severity of the trauma and the anatomical location of the injury were similar in the patients who died in the first 24 hours compared to the survivors.

In the clinical setting, the definition of an optimal SBP value must comply with being a point below which it is associated with an increased risk of mortality. For this reason, 70 mmHg is proposed as the critical point for SBP prior to REBOA, since this value is associated

with a gradual increase in estimated mortality. Additionally, this figure is associated with a high sensitivity, but regular specificity in the prediction of mortality at 24 hours, with an increase in the number of false positives that could potentially be detected, benefiting them with the use of REBOA. Although SBP has a moderate ability to predict mortality, it should be complemented by other factors, such as the response or not to resuscitation maneuvers [6,21].

Previously, with data from a single center, SBP values on admission associated with an increase in 24-hour mortality and cardiac arrest were estimated in patients undergoing aortic occlusion, regardless of whether it was endovascular or open. They reported that the SBP on admission of 60 mmHg is associated with a 50% higher probability of mortality and the SBP on admission of 70 mmHg, with a higher probability of cardiac arrest [14]. The data from the REBOA registries show a more conservative mortality, with an estimated mortality rise point of over 25%.

On the other hand, there are factors that could potentially interact in clinical outcomes, such as the response to hemostatic resuscitation efforts, time elapsed to achieve occlusion of the aorta or definitive control of the injury, transfusion requirements of blood products and comorbidities, among others [22,23]. Timely restoration of blood volume in initial trauma care improves patient survival and is a variable that is still under investigation regarding its role in resuscitation of patients managed with REBOA [24,25].

Among the strengths of this study is that it is the largest collection of patients with severe trauma who underwent REBOA, multicenter in nature, which allows having a sample size that can be associated with greater statistical power. However, it has limitations regarding possible differences in the definitions of the variables or the lack of standardization of trauma care between centers. There is a lack of uniformity in the quantification of resuscitation variables, such as the volume of crystalloids or blood components before REBOA placement and in the first 24 hours. Additionally, despite 24-hour mortality being reported, the cause of death or the source of the hemorrhage is not known.

Conclusion

A SBP value of 70 mmHg in patients with severe trauma and non-compressible bleeding from the torso may be the critical point for endovascular occlusion of the aorta, to improve patient survival, regardless of the mechanism of trauma. However, the SBP must be complemented with other clinical factors to make the timely decision.

Compliance with ethical standards

Informed consent: This study is excluded from obtaining informed consent from the patients included in the databases. The collaborating centers of the databases obtained their endorsement by the institutional and ethics committees prior to the collection of patient data.

Conflict of interest: The authors declare that they have no conflict of interest.

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Authors' contributions:

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- Acquisition, completion and validation of data: Elmer Palacios, Christian Delgado, Carlos Munar, Yaset Caicedo, Alexander Salcedo, José Julián Serna, Fernando Rodríguez, Alberto García, Carlos Serna, Carlos Ordoñez.
- Data analysis and interpretation: Yaset Caicedo, Alexander Salcedo, José Julián Serna, Fernando Rodríguez, Alberto García.
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