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Circulation-first trauma resuscitation and mortality: A 9-year single-center retrospective study

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BACKGROUND: Recent studies have proposed revising the conventional airway-breathing-circulation (ABC) sequence to a circulation-airway-breathing (CAB) approach. We evaluated the potential benefit of the CAB sequence, emphasizing the timing of blood transfusion in trauma resuscitation.

METHODS: We retrospectively analyzed data from the trauma registry and electronic medical records at our institution between March 2016 and February 2024. Adult trauma patients with systolic blood pressure of <90 mm Hg in the resuscitation room who underwent both endotracheal intubation and blood transfusion within 1 hour of arrival were included. To control for confounding factors, including demographics, vital signs, Injury Severity Score, and head/neck Abbreviated Injury Scale, logistic regression analysis was performed after propensity score matching.

RESULTS: A total of 690 patients met the inclusion criteria: 244 received transfusion before intubation (CAB group), and 446 were intubated before transfusion (ABC group). After propensity score matching, 231 patients were included in each group. Intubation occurred 14 minutes earlier, and transfusion occurred 11 minutes later in the ABC group than in the CAB group. Postintubation hypotension was more frequent in the ABC group (73% vs. 64%; $p = 0.046$), whereas unplanned intensive care unit admission was higher in the CAB group. The median hospital stay was shorter in the ABC group (25 [7–50] days) than in the CAB group (30 [14–50] days) ($p = 0.014$). In multivariable analysis, CAB resuscitation was independently associated with reduced 30-day mortality (adjusted odds ratio, 0.57; 95% confidence interval, 0.33–0.99; $p = 0.045$).

CONCLUSION: This study demonstrated that transfusion-first resuscitation (CAB) improved hemodynamic stability and 30-day survival compared with the conventional ABC sequence. Prioritizing circulation before airway management may reduce postintubation hypotension and guide future trauma resuscitation strategies. Further prospective multicenter studies are warranted to validate these findings. (*J Trauma Acute Care Surg.* 2025;00: 00–00. Copyright © 2025 The Author(s). Published by Wolters Kluwer Health, Inc. on behalf of the American Association for the Surgery of Trauma.)

LEVEL OF EVIDENCES: Therapeutic/Care Management; Level III.

KEY WORDS: Trauma; shock; resuscitation; circulation first; transfusion.

Since the American Heart Association revised its guidelines in 2010, changing the resuscitation sequence for cardiac arrest from airway-breathing-circulation (ABC) to circulation-airway-breathing (CAB), the principle of "don't pump an empty heart" has become a key concept in resuscitation practice.[1,2] That same year, Khalid and Juma[3] proposed a revision to the trauma resuscitation sequence by prioritizing circulation first, and several other authors have since explored the concept of circulation-first resuscitation.[4–10] In a study by Ferrada et al.,[10] blood transfusion was performed before intubation, and trauma resuscitation following the CAB sequence was associated with a decrease in 24-hour and 30-day mortality rates. The hemodynamic rationale for prioritizing circulation in trauma resuscitation (CAB sequence) is that performing intubation before adequately restoring circulating volume in a trauma patient with hypovolemic shock may reduce venous return owing to positive pressure ventilation, leading to decreased cardiac output and further hemodynamic compromise.[11] In addition, the administration of drugs that induce intubation in a state of hypovolemic shock may inhibit the action of catecholamines in the cardiovascular system, thereby causing hemodynamic collapse.[12] This hemodynamic instability that occurs postintubation is referred to as postintubation hypotension (PIH), which has been associated with an increased incidence of cardiac arrest and mortality in trauma patients.[13–15] Therefore, this study was conducted to verify the hypothesis that prioritizing blood transfusion through CAB resuscitation, rather than the conventional ABC resuscitation order, improves the survival rate of trauma patients with hemorrhagic shock.

PATIENTS AND METHODS

Patients

This study retrospectively analyzed data from the trauma registry and electronic medical records of our institution,

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registered in the Korea Trauma Data Bank, from March 2016 to February 2024. Our study was approved by the relevant institutional review board (approval number: blinded). As this was a retrospective study using medical records, the requirement for informed consent was waived. The STROBE guideline was followed to ensure proper reporting of methods, results, and discussion (Supplemental Digital Content, Supplementary Data 1, http://links.lww.com/TA/F2).

We included trauma patients who presented with shock, defined as a systolic blood pressure (SBP) of <90 mm Hg on arrival or during initial resuscitation in the trauma bay, and who received both endotracheal intubation and blood transfusion within 1 hour of arrival. The exclusion criteria were age younger than 16 years and prehospital cardiac arrest. Additionally, to control for confounding effects due to early death or cardiac arrest, patients who died or experienced cardiac arrest before the initiation of transfusion or intubation were excluded from the study. The recorded data included patient demographics, mechanism of injury, Injury Severity Score (ISS), Abbreviated Injury Scale (AIS), initial Glasgow Coma Scale (GCS) score, SBP on arrival and after intubation, pulse rate, intubation agents used, time of death, and complications (e.g., acute kidney injury, pneumonia, acute respiratory distress syndrome, deep vein thrombosis, pulmonary thromboembolism, and sepsis). Additional variables included blood gas analysis results, blood lactate and hemoglobin levels, hospital length of stay (LOS), and length of intensive care unit (ICU) stay. The primary outcomes of this study were 24-hour and 30-day mortality rates, and the secondary outcomes were hospital LOS, ICU LOS, in-hospital complications, and the occurrence of PIH. In our trauma center, the massive transfusion protocol is activated immediately upon recognition of hemorrhagic shock, typically defined as SBP of <90 mm Hg with evidence of active bleeding or hemodynamic instability. In cases categorized as CAB, transfusion was intentionally initiated immediately after massive transfusion protocol activation and before endotracheal intubation, reflecting the trauma team leader's real-time judgment to prioritize circulation in patients at risk of imminent collapse. This protocol-driven yet flexible decision-making framework was consistently applied throughout the study period.

Definition of ABC Versus CAB and PIH

Intubation and transfusion data were extracted from the registry by reviewing medical records. Based on the timing of these interventions, patients were classified into two groups: those who received transfusion before intubation were assigned

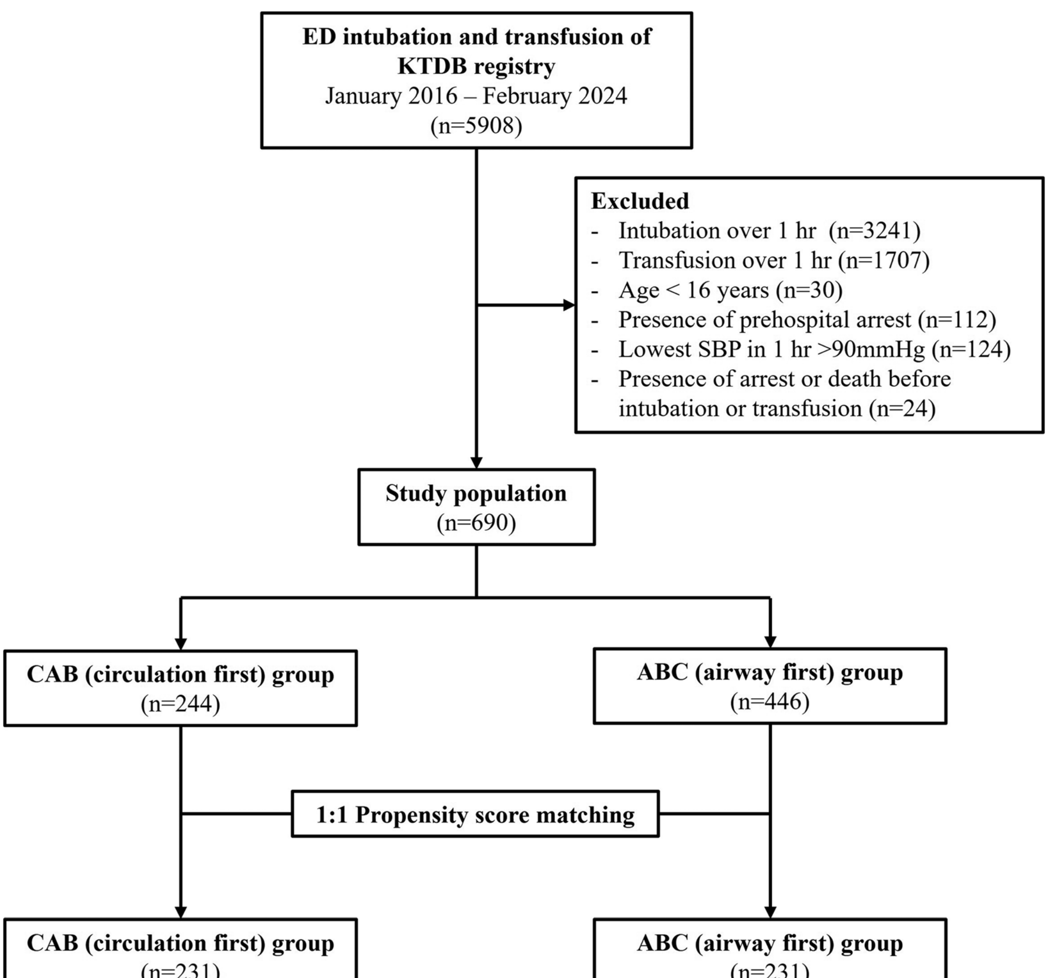

Figure 1. Flow diagram of patient selection and inclusion in the study. KTDB, Korea Trauma Data Bank.

to the CAB group, and those who underwent intubation before transfusion were assigned to the ABC group. Currently, as no standardized guideline exists on ABC or CAB sequencing in trauma care, the resuscitation order was determined at the discretion of the attending physician. In our country, prehospital blood transfusion is not yet institutionally implemented; therefore, no patients received prehospital transfusion.

Postintubation hypotension was defined as the occurrence of any of the following within 15 minutes after intubation[13,15]: (*a*) decrease in SBP to ≤80 mm Hg or a ≥20% reduction from baseline, (*b*) further SBP drop of ≥5 mm Hg in patients who experienced preintubation hypotension (defined as mean SBP ≤90 mm Hg), (*c*) decrease in mean arterial pressure to ≤60 mm Hg, or (*d*) administration of vasopressors, inotropic agents, or an increase in the infusion rate of these agents.

Statistical Analysis

After normality testing, continuous variables were compared between the CAB and ABC groups using Student's *t* test or the Mann-Whitney *U* test, as appropriate. Categorical variables were analyzed using Fisher's exact test or the χ^2 test. Outcome data are expressed as mean ± SD or median with interquartile range (IQR). Variables significantly associated with mortality in univariate analysis were included into a backward stepwise logistic regression to identify predictors of 24-hour and 30-day mortality. Kaplan-Meier survival analysis was used to evaluate cumulative survival over time between the CAB and ABC groups, and survival curves were generated accordingly. Statistical analyses were performed using R software (version 4.02; R Foundation for Statistical Computing, Vienna, Austria, 2022). Analyses were performed using R packages moonBook (version 0.3.1), epiDisplay (version 3.5.0.2), and survminer (version 0.4.9). Propensity score matching to adjust for confounding variables was performed using the MatchIt package. A 1:1 nearest neighbor matching was performed using a caliper of 0.2. A standardized mean difference of ≤0.1 was used as the threshold for adequate balance between matched groups. A *p* value of <0.05 was considered statistically significant.

RESULTS

Baseline Characteristics

During the 9-year study period, 5,908 patients underwent intubation and transfusion in the emergency department (ED). After applying the exclusion criteria, 690 patients were included in the analysis (Fig. 1). Among them, 244 patients received transfusion before endotracheal intubation (CAB group), whereas 446 patients underwent endotracheal intubation before transfusion (ABC group). The median (IQR) age and body mass index of the cohort were 52 (37–64) years and 24.3 (22.0–26.9) kg/m^2, respectively, with no significant differences between the groups (Table 1). Most patients were male (77%, n = 531), and the main mechanism of injury was blunt trauma (90%, n = 619), with no significant differences observed between the two groups. The median (IQR) SBP at admission was 104 (82–103) mm Hg, and it was significantly lower in the CAB group than in ABC group (90 [72–121] vs. 110 [89–131] mm Hg, $p < 0.001$). The median (IQR) diastolic blood pressure in the trauma bay was 66 (54–78) mm Hg, with no significant difference between the two groups. The median shock index was 1.0 (0.8–1.3), which was significantly higher in the CAB group than in ABC group (1.1 [0.8–1.4] vs. 1.0 [0.8–1.2], $p < 0.001$).

The median (IQR) GCS score was higher (13 [10–14] vs. 7 [3–12], $p < 0.001$), while the proportion of patients with a GCS score of ≤8 was lower (23%, n = 55 vs. 61%, n = 271; $p < 0.001$) in the CAB group than in the ABC group. To adjust for confounding factors, propensity score matching, using age, sex, injury mechanism, SBP, ISS, and AIS head and neck as matching variables, was performed, yielding 231 matched patients in each group (Table 2). After matching, most variables showed standardized mean differences <0.1, confirming adequate balance between groups (Table 2).

Preintubation SBP, Crystalloids, Induction Drugs, Dose, and PIH

Intubation was performed 14 minutes earlier, and transfusion was performed 13 minutes later in the ABC group than in the CAB group (Supplemental Digital Content, Supplementary Data 2, http://links.lww.com/TA/F3; Supplementary Data 3, http://links.lww.com/TA/F4). Although preintubation SBP did not differ significantly between groups, the CAB group received a higher volume of preintubation fluid (800 [500–1000] vs. 400 [200–700] mL, $p < 0.001$), transfused with 2 U of RBCs, and exhibited higher postintubation SBP (82 [65–102] vs. 74 [59–88] mm Hg, $p < 0.001$) than the ABC group. Postintubation hypotension occurred more frequently in the ABC group (73%, n = 168) than in the CAB group (64%, n = 147, $p = 0.046$).

No significant difference was observed in the rate of intubation with drug assistance between the two groups. The most commonly used induction drug was etomidate alone, followed by etomidate-succinylcholine and ketamin-succinylcholine. Ketamine alone was used significantly more often in the CAB group (6%, n = 14 vs. 2%, n = 2; $p = 0.030$). No significant difference was observed in the dose of induction agents between groups, indicating that the hemodynamic benefit of CAB likely derived from sequencing rather than anesthetic dosing.

Incidence of Hospital Events and Outcomes

Unplanned ICU admissions occurred more frequently in the CAB group, likely reflecting differences in injury distribution and postoperative monitoring rather than treatment-related complications (Table 3). Hospital LOS was shorter in the CAB group (25 [7–50] vs. 30 [14–50] days; $p = 0.014$), whereas ICU LOS and ventilator days did not differ significantly. Overall mortality was significantly higher in the ABC group (30%, n = 70) than in the CAB group (16%, n = 37; $p < 0.001$), as was 24-hour mortality (17%, n = 40 vs. 9%, n = 21, $p = 0.013$) and 30-day mortality (27%, n = 63 vs. 15%, n = 34, $p = 0.001$).

Logistic Regression for 24-Hour and 30-Day Mortality

In the multivariable logistic regression analysis, PIH, SBP <90 mm Hg, ISS >15, and shock index >1.4 were not associated with either 24-hour (Table 4) or 30-day mortality (Table 5). Only GCS score of ≤8, age older than 55 years, and massive transfusion were independent predictors of both 24-hour and 30-day mortality. Circulation-airway-breathing remained independently

TABLE 1. Baseline Characteristics of Trauma Patients With Shock

	ABC (n = 446)	CAB (n = 244)	Total (N = 690)	p
Time to transfusion, median (IQR), min	23 (13–35)	10 (7–14)	15 (10–29)	**<0.001**
Time to intubation, median (IQR), min	6 (4–9)	20 (14–26)	9 (5–18)	**<0.001**
Age, median (IQR), y	52 (36–64)	52 (39–65)	52 (37–64)	0.775
≥55, n (%)	199 (45)	114 (47)	313 (45)	0.652
Sex, male, n (%)	347 (78)	184 (75)	531 (77)	0.536
BMI, median (IQR), kg/m^2	24.2 (22.0–26.8)	24.5 (22.1–27.0)	24.3 (22.0–26.9)	0.704
Mechanism of injury: blunt, n (%)	406 (91)	213 (87)	619 (90)	0.158
On-admission vital signs, median (IQR)				
SBP, mm Hg	110 (89–131)	90 (72–121)	104 (82–130)	**<0.001**
SBP ≤90, n (%)	119 (27)	122 (50)	241 (35)	**<0.001**
Lowest SBP in the ED	67 (53–79)	64 (54–78)	66 (54–78)	0.237
Pulse rate, mean ± SD, min^{-1}	109 ± 25	106 ± 25	108 ± 25	0.124
Shock index	1.0 (0.8–1.2)	1.1 (0.8–1.4)	1.0 (0.8–1.3)	**0.001**
>1.4, n (%)	70 (16)	64 (26)	134 (20)	**0.001**
GCS score, total	7 (3–12)	13 (10–14)	9 (5–14)	**<0.001**
GCS score ≤8, n (%)	271 (61)	55 (23)	326 (47)	**<0.001**
Hb, median (IQR), mg/dL	11.4 (9.6–12.9)	11.0 (9.6–12.4)	11.2 (9.6–12.7)	0.156
Base excess, mmol/L	−8.1 (−11.9 to −5.3)	−7.7 (−11.3 to −5.8)	−7.9 (−11.6 to −5.5)	0.549
Lactate, mmol/L	5.47 (3.74–8.37)	5.68 (3.87–8.02)	5.56 (3.75–8.21)	0.917
ED LOS, median (IQR), min	49 (40–60)	49 (39–61)	49 (39–60)	0.985
ED disposition, n (%)				**<0.001**
ICU	264 (59)	97 (40)	361 (52)	
Operating room or IR	180 (41)	146 (60)	326 (47)	
General ward	0 (0.0)	1 (0)	1 (0)	
Comorbidity, n (%)				
HTN on medication	110 (25)	57 (23)	167 (24)	0.773
Diabetes mellitus	67 (15)	36 (15)	103 (15)	1.000
Cerebrovascular disease	12 (3)	6 (2)	18 (3)	1.000
Liver disease	6 (1)	7 (3)	13 (2%)	0.265
Angina	4 (1)	3 (1)	7 (1)	0.984
Transfusion, median (IQR)				
RBC 24-h unit	9 (5–15)	12 (8–18)	10 (6–16)	**<0.001**
Massive transfusion, n (%)	212 (48)	162 (66)	374 (54)	**<0.001**
ISS, median (IQR)	34 (24–43)	33 (22–43)	34 (22–43)	0.304
AIS ≥3, n (%)				
Head and neck	237 (53)	55 (23)	292 (42)	**<0.001**
Face	16 (9)	2 (4)	18 (8)	0.269
Thorax	336 (93)	173 (90)	509 (92)	0.287
Abdomen	168 (62)	118 (67)	286 (64)	0.333
Extremity	213 (62)	155 (81)	368 (69)	**<0.001**

Values are presented as n (%) or median (IQR), unless otherwise indicated. Bold values indicate statistical significance.
BMI, body mass index; FFP, fresh frozen plasma; HTN, hypertension; IR, interventional radiology; RBC, red blood cell.

associated with lower 30-day mortality (adjusted odds ratio, 0.57 [0.33–0.99]; p = 0.045), although this represents association rather than causation.

Kaplan-Meier Survival Analysis of the CAB Versus ABC Group for 24-Hour and 30-Day Mortality

Kaplan-Meier survival curves and numbers at risk for 24-hour and 30-day mortality are presented in Figure 2. Significant survival differences were observed between groups at both 24 hours (log-rank p = 0.01) and 30 days (log-rank p < 0.001).

DISCUSSION

Since the American Heart Association recommended the CAB resuscitation algorithm for cardiac arrest in 2010, compression-first resuscitation has become an important paradigm in emergency care.[1,16] In contrast, Advanced Trauma Life Support protocols continue to follow the traditional ABCDE sequence of resuscitation.[17–19] Although several studies have explored CAB resuscitation in trauma settings, most were retrospective and contextually heterogeneous, and high-quality evidence

TABLE 2. Baseline Characteristics Before and After Propensity Score Matching

	Original Cohort			Post–Propensity Score Matching Cohort		
	ABC (n = 446)	CAB (n = 244)	SMD	ABC (n = 231)	CAB (n = 231)	SMD
Age, median (IQR), y	52 (36–64)	52 (39–65)	0.02	52 (37–65)	52 (39–65)	0.00
BMI, median (IQR), kg/m^2	24.2 (22.0–26.8)	24.5 (22.1–27.0)	0.05	24.5 (21.8–27.0)	24.4 (21.9–26.8)	0.01
Sex, male, n (%)	347 (78)	184 (75)	0.06	177 (77)	173 (75)	0.04
Injury mechanism: blunt, n (%)	406 (91)	213 (87)	0.08	204 (88)	203 (88)	0.01
SBP, median (IQR), mm Hg	110 (89–131)	90 (72–121)	0.42	101 (81–121)	93 (75–122)	0.09
Pulse rate, mean ± SD, min^{-1}	109 ± 25	106 ± 25	0.12	109 ± 27	107 ± 25	0.10
GCS, median (IQR)	7 (3–12)	13 (10–14)	0.82	8 (5–13)	13 (10–15)	0.65
Shock index, median (IQR)	1.0 (0.8–1.2)	1.1 (0.8–1.4)	0.30	1.0 (0.8–1.4)	1.1 (0.9–1.4)	0.04
>1.4, n (%)	70 (16)	64 (26)	0.26	51 (23)	55 (24)	0.03
Transfusion						
RBC (24 h), median (IQR), U	9 (5–15)	12 (8–18)	0.24	11 (6–17)	12 (8–18)	0.00
Massive transfusion, n (%)	212 (48)	162 (66)	0.38	131 (57)	150 (65)	0.17
ED LOS, median (IQR), min	49 (40–60)	49 (39–61)	0.03	49 (40–61)	49 (39–62)	0.03
ISS, median (IQR)	34 (24–43)	33 (22–43)	0.04	30 (22–43)	29 (22–43)	0.02
AIS, head and neck, n (%)			0.61			0.03
1	3 (1)	5 (5)		3 (3)	5 (5)	
2	47 (16)	32 (35)		27 (30)	32 (35)	
3	90 (31)	33 (36)		31 (34)	33 (36)	
4	48 (17)	9 (10)		12 (13)	9 (10)	
5	97 (34)	11 (12)		17 (19)	11 (12)	
6	2 (1)	2 (2)		0 (0)	2 (2)	
Comorbidity, n (%)						
HTN with medication	110 (25)	57 (23)	0.03	56 (24)	52 (22)	0.04
Diabetes mellitus	67 (15)	36 (15)	0.01	34 (15)	33 (14)	0.01
Cerebrovascular disease	12 (3)	6 (2)	0.01	8 (4)	6 (3)	0.05
Liver disease	6 (1)	7 (3)	0.11	4 (2)	5 (2)	0.03
Angina	4 (1)	3 (1)	0.03	2 (1)	3 (1)	0.04

Values are presented as n (%) or median (IQR), unless otherwise indicated.
BMI, body mass index; FFP, fresh frozen plasma; HTN, hypertension; RBC, red blood cell; SMD, standardized mean difference.

remains limited.[3–10,20] Therefore, this study aimed to assess the potential benefits of prioritizing circulation (i.e., transfusion) over airway management (i.e., intubation) during trauma resuscitation.

We analyzed data from 690 trauma patients with confirmed shock who underwent endotracheal intubation and blood transfusion in the resuscitation room. To minimize potential bias from baseline imbalances between the two groups, propensity score matching was performed using key covariates, including age, sex, mechanism of injury, SBP, ISS, and head/neck AIS, yielding 231 matched patients in each group. After matching, most variables showed a standardized mean difference below 0.1, confirming adequate balance between the groups. Importantly, the differences in 30-day mortality between the CAB and ABC groups remained consistent after matching, suggesting that the survival benefit observed in the CAB group was not solely attributable to baseline differences. This reinforces the robustness of our findings and supports the clinical relevance of prioritizing circulation-first resuscitation in trauma patients with hemorrhagic shock. Mortality was markedly lower in the CAB group, and this association persisted after propensity matching, reinforcing the robustness of our findings. In the multivariate analysis, the odds ratio for 30-day mortality in the CAB group was 0.57 (0.33–0.99). Our results align with those of Ferrada et al.,[10] who reported an odds ratio of 0.11 (0.05–0.23) for 30-day mortality in the CAB group. Notably, Ferrada et al.[10] also reported that 39% of patients in the CAB group underwent endotracheal intubation in the operating room rather than in the ED, a factor that may have contributed to their lower mortality rate. The finding that endotracheal intubation in the operating room, rather than in the ED, is associated with reduced in-hospital arrest and mortality was also confirmed by Dumas et al.[21] and Dunton et al.[22]

Delaying endotracheal intubation in the operating room during the resuscitation process may be dangerous, as some patients may require immediate airway protection. Previous studies often included patients who were stable enough to tolerate delayed intubation until reaching the operating room, which may limit the generalizability of their results.[10,21,22] In contrast, our study included patients who underwent both intubation and blood transfusion in the resuscitation room. Notably, no significant differences were observed in ED LOS or incidence of in-hospital cardiac arrest between the ABC and CAB groups. Therefore, our findings may help estimate the survival benefit of prioritizing transfusion before intubation in the resuscitation room.

The potential harm of initiating resuscitation with intubation in trauma patients with shock can be attributed to decreased

TABLE 3. Clinical Outcomes and Major Hospital Events

	ABC (n = 231)	CAB (n = 231)	*p*
Hospital LOS, median (IQR), d	25 (7–50)	30 (14–50)	**0.014**
ICU LOS, median (IQR), d	8 (3–18)	9 (4–17)	0.384
Ventilator duration, median (IQR), d	4 (1–13)	4 (2–12)	0.792
Overall mortality, n (%)	70 (30)	37 (16)	**<0.001**
24-h Mortality, n (%)	40 (17)	21 (9)	**0.013**
30-d Mortality, n (%)	63 (27)	34 (15)	**0.001**
Major hospital events, n (%)			
AKI	24 (10.4)	16 (6.9)	0.247
ARDS	11 (4.8)	8 (3.5)	0.639
Arrest with CPR	22 (9.5)	24 (10.4)	0.877
Deep SSI	9 (3.9)	7 (3.0)	0.799
DVT	5 (2.2)	12 (5.2)	0.138
Organ SSI	3 (1.3)	5 (2.2)	0.721
Pneumonia	46 (19.9)	42 (18.2)	0.722
PTE	1 (0.4)	7 (3.0)	0.075
Stroke	6 (2.6)	5 (2.2)	1.000
Superficial SSI	4 (1.7)	7 (3.0)	0.542
UTI	5 (2.2)	10 (4.3)	0.294
CRBSI	6 (2.6)	5 (2.2)	1.000
Unplanned intubation	10 (4.3)	12 (5.2)	0.827
Unplanned return to operating room	25 (10.8)	27 (11.7)	0.883
Unplanned ICU admission	6 (2.6)	18 (7.8)	**0.021**
Sepsis	11 (4.8)	18 (7.8)	0.250
GOS, median (IQR)	2 (1–5)	4 (2–5)	**0.000**
Discharge disposition, n (%)			**0.001**
Death	70 (30)	37 (16)	
Home	41 (18)	53 (23)	
Transfer	120 (52)	141 (61)	

Values are presented as n (%) or median (IQR), unless otherwise indicated. Bold values indicate statistical significance.
AKI, acute kidney injury; ARDS, acute respiratory distress syndrome; CRBSI, catheter-related bloodstream infection; DVT, deep vein thrombosis; GOS, Glasgow Outcome Scale; PTE, pulmonary thromboembolism; SSI, surgical site infection; UTI, urinary tract infection.

venous return and depletion of intravascular volume caused by intubation and positive pressure ventilation.[6,10] In a 2021 study of rapid sequence intubation in patients with traumatic hemorrhage among US military personnel, Emerling et al.[23] reported the impact of preintubation blood products. They found that the odds ratios (95% confidence interval) for adverse outcomes in patients without preintubation transfusion were 3.8 (0.7–21.5) for 24-hour mortality, 1.3 (0.4–4.7) for 30-day mortality, 18.5 (1.2–279.3) for pulseless arrest, and 9.4 (2.3–38.0) for a ≥ 30% decrease in SBP. Physiologically, intubation and positive-pressure ventilation can exacerbate cardiovascular collapse in patients with hemorrhagic shock by reducing venous

TABLE 4. Logistic Regression Analyses for 24-Hour Mortality

	Univariable Analysis		Multivariable Analysis	
	Crude OR (95% CI)	Crude *p*	Adjusted OR (95% CI)	*p*
CAB (vs. ABC)	0.49 (0.27–0.87)	0.015	0.60 (0.31–1.16)	0.124
Age ≥55 y	1.66 (0.95–2.90)	0.077	1.88 (1.02–3.48)	**0.043**
SBP <90 mm Hg	1.13 (0.65–1.98)	0.666	1.37 (0.63–3.00)	0.433
GCS ≤8	4.15 (2.32–7.44)	<0.001	4.99 (2.59–9.64)	**<0.001**
Massive transfusion	4.55 (2.10–9.85)	<0.001	5.79 (2.37–14.19)	**<0.001**
Shock index >1.4	1.21 (0.64–2.28)	0.558	0.83 (0.35–1.96)	0.670
Head and neck AIS ≥3	0.61 (0.30–1.25)	0.180	0.37 (0.16–0.84)	**0.012**
ISS >15	0.93 (0.40–2.17)	0.868	0.44 (0.16–1.27)	0.142
PIH present	2.09 (1.05–4.17)	0.036	1.54 (0.73–3.25)	0.246

Bold values indicate statistical significance. Log-likelihood, −141.0054; number of observations, 456; AIC, 302.0108.
AIC, Akaike Information Criterion; CI, confidence interval; OR, odds ratio.

TABLE 5. Logistic Regression Analyses for 30-Day Mortality

	Univariable Analysis		Multivariable Analysis	
	Crude OR (95% CI)	Crude *p* value	Adjusted OR (95% CI)	*p*
CAB (vs. ABC)	0.49 (0.30–0.78)	0.003	0.57 (0.33–0.99)	**0.045**
Age ≥55 y	2.05 (1.28–3.26)	0.003	2.52 (1.48–4.30)	**<0.001**
SBP <90 mm Hg	1.29 (0.81–2.04)	0.287	1.23 (0.64–2.37)	0.532
GCS ≤8	4.53 (2.79–7.36)	<0.001	5.04 (2.87–8.87)	**<0.001**
Massive transfusion	4.95 (2.66–9.22)	<0.001	6.29 (3.09–12.83)	**<0.001**
Shock index >1.4	1.43 (0.85–2.39)	0.180	0.92 (0.45–1.90)	0.828
Head and neck AIS ≥3	1.28 (0.76–2.14)	0.350	0.78 (0.42–1.45)	0.433
ISS >15	1.73 (0.75–3.97)	0.196	0.78 (0.29–2.10)	0.621
PIH present	1.28 (0.77–2.13)	0.347	0.85 (0.47–1.53)	0.588

Bold values indicate statistical significance. Log-likelihood, −183.0255; number of observations, 456; AIC, 386.0511.
AIC, Akaike Information Criterion; CI, confidence interval; OR, odds ratio.

return to the heart, which may explain the markedly increased risk of pulseless arrest observed in the no-blood-product group.[23–25] Furthermore, the medications used for drug-assisted intubation can interfere with the body's compensatory responses to shock.[10,12,26] The γ-aminobutyric acid, opioid, and *N*-methyl-D-aspartate receptors in the autonomic nervous system are major targets of induction agents that modulate cardiovascular tone.[27] The dosage of these agents is directly related to hemodynamic stability, and standard dosing can excessively suppress autonomic activity in patients with depleted intravascular volume, leading to severe hypotension or cardiovascular collapse.[25] Accordingly, multiple guidelines recommend dose reduction of induction agents in patients with hemorrhagic shock.[25,28,29] Collectively, these physiologic mechanisms provide a compelling rationale for prioritizing circulatory stabilization before airway intervention in trauma patients with hemorrhagic shock, reinforcing the translational importance of the CAB concept while highlighting its mechanistic plausibility rather than definitive proof.

Delayed recovery from shock is associated with an increased risk of organ dysfunction and late mortality.[17,19] Therefore, restoring intravascular volume before intubation may improve outcomes. Various studies have defined the decrease in blood pressure that occurs after intubation as PIH and analyzed its adverse effects.[15,30,31] Anand et al.[15] reported that the in-hospital mortality rate among patients who developed PIH was twice as high as that among patients who did not develop PIH.[15] They also found that preintubation hypertonic saline challenge and vasopressor use were independent protective factors against PIH. Patients who received transfusion prior to intubation (CAB group) had a significantly lower incidence of PIH and improved survival, despite lower initial SBP. In our study, the CAB group underwent intubation approximately 14 minutes later than did the ABC group, allowing more time for crystalloid infusion and transfusion. Although the on-arrival SBP was lower in the CAB group, the incidence of PIH was only 64%, and the 30-day mortality was 50% of that of the ABC group. However, multivariate analysis did not confirm a significant association between PIH and mortality. These findings warrant validation through well-designed, prospective multicenter studies.

In this study, major hospital events, such as unplanned ICU admission, were observed more frequently in the CAB group, likely reflecting cohort characteristics rather than treatment-related complications. The CAB group had a lower initial SBP and began transfusion earlier. Because of these cohort characteristics, the transfusion volume of RBC in the CAB group was higher than that in the ABC group. After adjusting for confounding factors, unplanned ICU admission remained the only hospital event that showed a statistically significant difference in the CAB group following propensity score matching. The reason for unplanned ICU admission was desaturation with dyspnea in the ABC group and postoperative monitoring in the CAB group. These differences likely reflect variations in injury distribution rather than adverse effects of the CAB sequence. The ABC group had a higher incidence of chest AIS score of ≥3, whereas the CAB group had a higher incidence of extremity AIS score of ≥3, which may have resulted in more frequent surgical intervention. After propensity score matching, no significant differences were observed in the incidence of sepsis or deep vein thrombosis between the ABC and CAB groups. The results showing that the CAB group had more unplanned ICU readmissions were similar to the findings of Lee and Kang,[32] in which activation of the massive transfusion protocol was independently associated with unplanned ICU readmissions.

These findings should also be interpreted in light of previous multicenter studies demonstrating that higher transfusion volumes are independently associated with increased risks of infection, venous thromboembolism, and prolonged ICU stay. For example, Inaba et al.[33] reported a dose-dependent relationship between transfusion volume and posttrauma infection and VTE rates in a large multicenter cohort, while Shih et al.[34] similarly showed that excessive transfusion exposure correlated with increased sepsis and ICU LOS in trauma patients. Taken together, our observation of comparable infection-related complication rates between CAB and ABC groups after matching suggests that early transfusion within the CAB framework may not necessarily exacerbate transfusion-related morbidity.

This study has some limitations. First, it was a retrospective observational study conducted at a single institution; we attempted to adjust for confounding factors by performing propensity score matching and logistic regression analysis but could not completely overcome this limitation. Therefore, a degree of

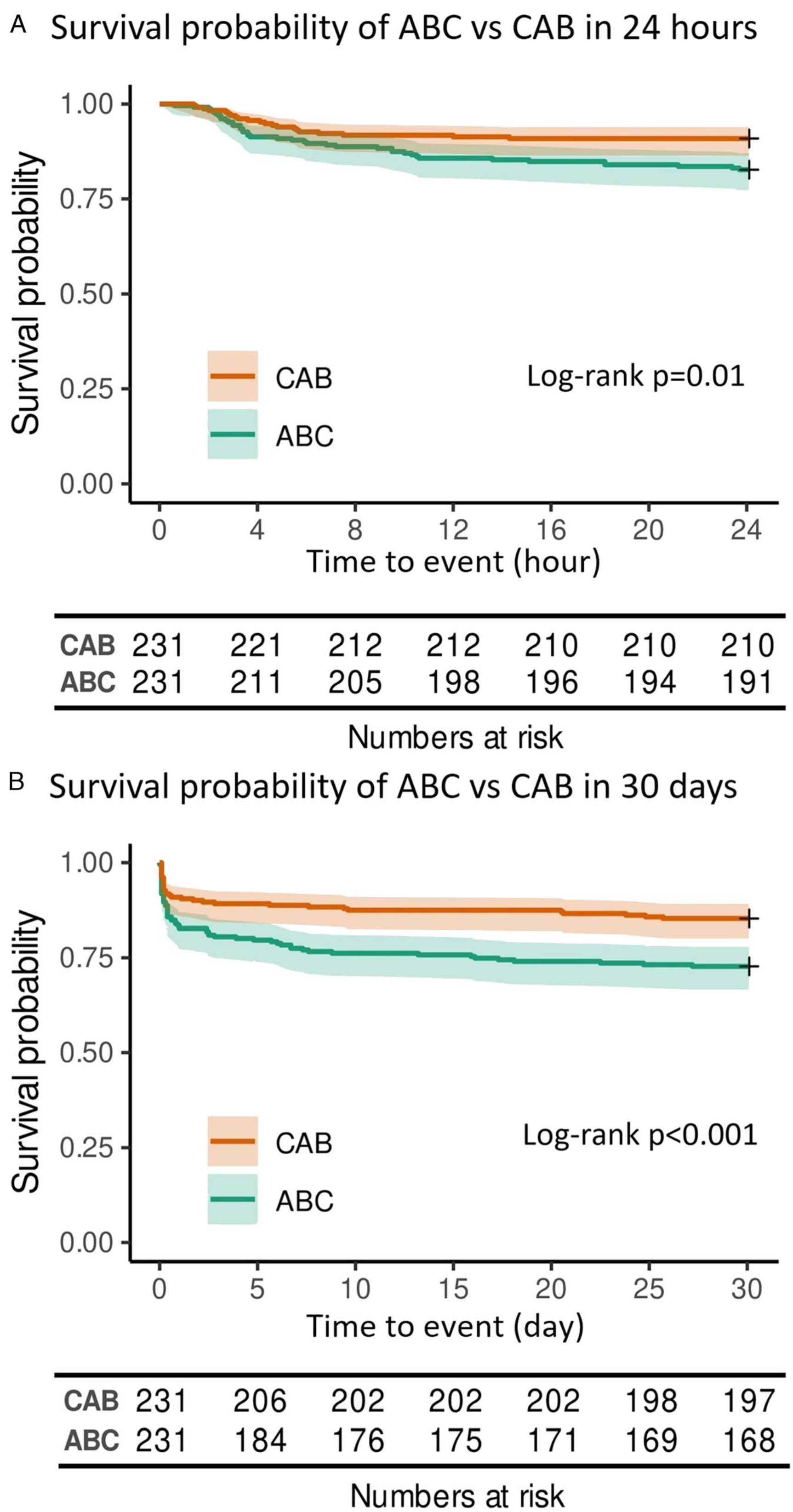

Figure 2. Kaplan-Meier survival curves comparing the CAB and ABC groups for 24-hour and 30-day mortality.

selection bias may persist. Second, because the two groups were not administered identical volumes of fluids and drug doses before intubation, the effects of transfusion could not be quantitatively isolated from concurrent fluid administration, limiting mechanistic interpretation. Therefore, the generalizability of the results of this study is limited. Third, although the type of induction drugs used was recorded, subgroup analysis was not performed because of the small sample size. In patients with shock, the type and combination of intubation-inducing drugs may contribute to adverse outcomes and may be a significant factor in the development of PIH.[35,36] Therefore, follow-up studies with subgroup analysis for drug type and combination are necessary. Fourth, although the head and neck and extremity scores (AIS score, ≥3) were adjusted in our propensity score matching and logistic regression model, intergroup differences in GCS were not fully controlled. In particular, severe traumatic brain injury remains a major cause of death in trauma patients and may present a physiological profile distinct from hypovolemic shock. Therefore, future large-scale prospective studies are needed to validate these results while controlling for the distribution and severity of injuries by anatomical site.

Despite these limitations, this study has notable strengths. To the best of our knowledge, no previous reports have investigated whether transfusion-first versus endotracheal intubation-first resuscitation leads to different outcomes in trauma patients with shock managed in the trauma bay. Unlike most prior studies that included patients who were stable enough to undergo delayed intubation in the operating room, our study focused on patients who received both blood transfusion and intubation in the trauma bay. Therefore, this study holds academic significance, as it analyzed the role of the CAB sequence in early trauma resuscitation. Similar to how extensive prospective research has shifted the paradigm of resuscitation for cardiac arrest toward the CAB sequence, the trauma field may similarly benefit from a comparable shift supported by well-designed, controlled, multicenter prospective studies. The growing emphasis on prehospital transfusion reflects this evolving perspective. In our study, patients in the CAB group received an average of 2 U of RBCs approximately 10 minutes before tracheal intubation, which was associated with a reduced incidence of PIH and improved survival. Although this retrospective single-center study does not establish causality, the observed association underscores the potential clinical importance of preintubation transfusion. Our findings suggest that early circulation control, including preintubation transfusion, could be considered in future revisions of trauma algorithms, pending confirmation from large-scale prospective trials.

In conclusion, resuscitation following a circulation-first sequence (CAB), in which transfusion precedes intubation, was associated with lower PIH incidence and improved 30-day survival among trauma patients with shock. These findings represent an association rather than proof of causation and should be confirmed in future multicenter prospective studies.

AUTHORSHIP

D.C. and K.J. contributed in the conception and study design, literature review, data acquisition, data analysis and interpretation, drafting of the manuscript, critical revision, funding acquisition, investigation, methodology, project administration, resources, software, validation, and approval of final manuscript. K.J. performed the supervision, and D.C. performed the visualization of the work.

DISCLOSURE

Conflicts of Interest: Author Disclosure forms have been supplied and are provided as Supplemental Digital Content (http://links.lww.com/TA/E1000).
Ethics Approval and Consent to Participate: Our study was approved by the institutional review board (IRB approval number: AJOUIRB-DB-2025-216). This was a retrospective study using medical records, and the results were obtained from a general treatment course. As the risk to patients is extremely low, consent can be waived.
Availability of Data and Materials: The data supporting the results of this study are available at the Clinical Research Information Service (https://cris.nih.go.kr/cris/index/index.do) under study number KCT0010594.

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