BPR MCS | Bulletin of Pioneering Researches of Medical and Clinical Science

Bulletin of Pioneering Researches of Medical and Clinical Science

Available online: https://bprmcs.com
2026 | Volume 6 | Issue 1 | Page: 30-39

Percutaneous Dilatational Tracheostomy in Hematologic Malignancy: Safety Profile and Clinical Outcomes

Claire Dupont[1]*, Julien Martin[1]

[1]Department of Medical and Clinical Investigation, University of Bordeaux, Bordeaux, France.

Abstract

Individuals diagnosed with hematologic malignancy (HM) commonly face elevated incidences of thrombocytopenia, thrombocytopathy, anemia, leukopenia, and coagulopathy. These conditions can markedly heighten the likelihood of complications arising during or after medical procedures. The present study was designed to investigate the safety profile and clinical outcomes of percutaneous dilatational tracheostomy (PDT) in critically ill patients with HM. A retrospective cohort analysis was conducted on patients with HM who received PDT between 2012 and 2023 in a tertiary academic medical facility. The main endpoint focused on the frequency of early bleeding complications occurring within 7 days. Additional endpoints included mortality directly linked to PDT, as well as death rates at 1 week, 30 days, and 1 year. All statistical evaluations relied on a propensity score-matched cohort to achieve comparable groups for analysis. Of the 1627 patients evaluated, 65 (4%) were identified as having HM. Those with HM presented with a notably elevated Charlson comorbidity index and demonstrated substantially increased prevalence of thrombocytopenia (defined as platelet count below 100,000/mcL) relative to non-HM patients (8.0 [IQR 5.0–11.3] vs. 5.0 [IQR 2.0–7.0], P < 0.001; and 49.2% vs. 5.0%, P < 0.001, respectively). After propensity score matching, the mortality rate at 1 week was markedly higher in the HM cohort (23.4% vs. 4.3%, P = 0.007). In contrast, intraoperative complications, bleeding events, and mortality at one year showed no meaningful differences across the groups. Percutaneous dilatational tracheostomy (PDT) appears to be a safe intervention for critically ill patients with HM. That said, this population experiences notably elevated mortality in the immediate postoperative period.

Keywords: Tracheostomy, Complications, Hemorrhage, Percutaneous, Dilatational, Intensive care unit

Corresponding author: Claire Dupont
E-mail: claire.dupont@gmail.com

Received: 14 September 2025
Revised: 12 January 2026
Accepted: 21 January 2026

How to Cite This Article: Dupont C, Martin J. Percutaneous Dilatational Tracheostomy in Hematologic Malignancy: Safety Profile and Clinical Outcomes. Bull Pioneer Res Med Clin Sci. 2026;6(1):30-9. https://doi.org/10.51847/qSuxvUAZvO

Introduction

Hematologic malignancies (HM) represent a broad spectrum of diseases that originate in the bone marrow or lymphatic system. In the United States, approximately 1.4 million people are currently living with or have achieved remission from these conditions. In 2019, roughly 176,200 new diagnoses of HM were recorded, accounting for 10% of all newly diagnosed cancer cases [1-3].

Management approaches for hematologic malignancies have evolved considerably in recent times [4]. Combined with better supportive therapies, these innovations have contributed to improved longevity for HM patients. At the same time, such advances have produced a larger pool of individuals at risk for severe, life-endangering issues that often demand intensive care unit (ICU) admission [5-7]. Data indicate that about 14% of HM patients require ICU care during the initial year after their diagnosis [7]. In the

past, mortality rates within the ICU for this group were documented as high as 90% [8-10]. More contemporary reports from specialized high-volume institutions, however, point to a decline, with figures now falling to 50% or below [8].

Acute respiratory failure stands out as a frequent and dangerous issue in patients with HM. For those admitted to the ICU, it explains 60% to 80% of all cases [11]. It remains the leading cause of ICU entry, affecting 10–20% of individuals with lymphoma or leukemia and nearly 50% of those experiencing neutropenia or recovering from bone marrow transplantation [12, 13]. The condition carries especially poor survival odds, above all in people who need mechanical ventilation or who have undergone allogeneic bone marrow transplant [14, 15]. Although approximately half of affected patients do not survive, recent trends suggest gradual gains in overall survival [16]. Even so, certain patients who overcome the immediate crisis may later face persistent respiratory insufficiency due to muscle weakness or underlying lung pathology, often leading to the need for extended ventilatory support.

Tracheostomy procedures are used in 10%–20% of cases involving long-term mechanical ventilation, and their use has grown steadily over the last 20 years [17, 18]. While exact figures for HM patients have not been determined, the need for tracheostomy in this group is likely greater than in the broader population of critically ill individuals with respiratory compromise. This expectation stems from the fact that HM itself functions as an independent risk factor for difficult weaning and subsequent tracheostomy dependence [19].

Percutaneous dilatational tracheostomy (PDT) was first described in 1955 [20]. Over the past several years, this technique has become the go-to method for critically ill individuals who require prolonged mechanical ventilation. PDT has now largely supplanted the older open surgical tracheostomy approach in most ICU settings, mainly due to its clear benefits: it is straightforward to perform, has lower complication rates, eliminates the need for additional patient transfers, and is more economical overall. Additionally, performing PDT at the patient's bedside bypasses the drawbacks of extended operating room booking delays, thereby greatly reducing the time between deciding on a tracheostomy and completing it [21]. Research has established that PDT can be conducted safely even among high-risk surgical cases, such as people with severe obesity, blood-clotting disorders, liver cirrhosis, or those taking dual antiplatelet medications [22-26]. People living with hematologic malignancies (HM) frequently show high levels of thrombocytopenia, anemia, leukopenia, and coagulopathy; these factors significantly raise the chances of problems both during and after the procedure, especially bleeding events, damage to the airway, and infections at the surgical site [27].

Until now, no published information has compared how safe PDT is or how often complications arise in patients with hematologic malignancies versus those who do not have such blood disorders. Therefore, the main goal of our research was to examine the safety profile, particularly the bleeding risk, associated with PDT in critically ill patients with HM. We expected that individuals with HM would show noticeably different results compared with other critically ill patients, largely because of their specific starting health conditions and greater vulnerability to bleeding issues.

Materials and Methods

Study design and settings

The Institutional Review Board of Rambam Health Care Center in Haifa, Israel, approved this retrospective cohort study. The requirement for informed consent was waived (approval number: 0143-21-RMB).

We conducted a detailed chart review to identify all critically ill patients who had undergone PDT between January 2012 and March 2023. Rambam Health Care Center operates as a 1,000-bed tertiary academic hospital. It serves as the region's only Level I trauma and burn center, caring for a population of more than 2 million people. The hospital maintains medical, surgical, burn, neurosurgical, and cardiothoracic intensive care units, as well as six intermediate care units.

Only elective PDT procedures performed because of the need for long-term mechanical ventilation were included in the study. Any patients who required an emergency tracheostomy or who underwent the procedure due to maxillofacial trauma or tumors causing airway blockage were left out.

The study group comprised all patients with an active hematologic malignancy (HM) identified using ICD-10 codes and definitions from the Hematological Malignancy Research Network, with all diagnoses double-checked during the chart review. These patients were then separated into three categories based on their predicted survival: good (> 70% 5-year survival), medium (30%–70%), and poor (< 30%) [28]. For comparison, patients confirmed by chart review to have no hematologic malignancy were included as the control group.

PDT procedure

Throughout the study period, all percutaneous dilatational tracheostomies were performed exclusively by experienced intensivists, otolaryngologists, or thoracic surgeons. In accordance with established recommendations from the American Thoracic Society, the European Respiratory Society, and the American

College of Chest Physicians, every operator had completed at least 30 prior PDT procedures [29, 30].

All interventions occurred at the bedside and utilized the modified Ciaglia method. The kits employed were either Blue Rhino (Cook Critical Care, Bloomington, IN, USA) or Portex Ultraperc™ (Smith Medical, Hythe, Kent, UK), paired with cuffed tracheostomy tubes sized 7.5 or 8 mm [21]. Adequate sedation and analgesia were first achieved using intravenous propofol at 1.5 mg/kg or midazolam in doses of 5–10 mg combined with fentanyl 50–100 μg. Neuromuscular blockade was then induced with rocuronium (0.6–1.2 mg/kg) when the anesthesiologist considered it appropriate. Patients were positioned supine, with a towel roll placed beneath the shoulders to promote neck extension. In cases involving cervical spine injury, a neutral neck position was strictly maintained. Ventilation settings included volume control mode, an inspired oxygen fraction (FiO2) of 1.0, and a positive end-expiratory pressure (PEEP) of 5 cmH_2O.

Local anesthesia was administered by infiltrating 2% lidocaine, after which a 10 mm midline incision was created directly over the trachea at the second tracheal ring level. Blunt dissection of the subcutaneous layers down to the trachea was performed using a hemostat clamp, and the tracheal rings were identified through palpation. With the aid of direct laryngoscopy, the existing endotracheal tube was pulled back until its cuff rested above the vocal cords. Puncture of the trachea was achieved with a 14-gauge introducer needle, and intraluminal location was verified by aspirating air through a syringe containing saline. Following the Seldinger technique, a J-tipped guidewire was passed through the needle, which was then withdrawn. Dilation began with a 14 Fr dilator and continued with progressively larger dilators of appropriate size. A preloaded cuffed tracheostomy tube was subsequently advanced over the final dilator into the tracheal lumen.

Confirmation of correct tube placement relied on bilateral breath sounds via chest auscultation and monitoring of end-tidal CO_2 ($EtCO_2$) levels. The tracheostomy tube was fastened securely with sutures and a necktie, followed by a routine portable chest X-ray. When the procedure was expected to present technical challenges, the attending physician could opt for additional real-time ultrasound imaging or bronchoscopic guidance.

Anticoagulation management involved temporarily stopping thromboprophylaxis with either low-molecular-weight heparin or unfractionated heparin for 12 hours. Full therapeutic anticoagulation was suspended for at least 24 hours before the intervention. Prophylactic doses were restarted 12 hours after completion of the procedure, whereas therapeutic anticoagulation was resumed after 24 hours. Immediately before PDT, patients with a platelet count below 50,000/μL received platelet concentrates, and those with an INR above 1.5 received fresh-frozen plasma (FFP) at the discretion of the responsible physician. Any patient currently prescribed dual antiplatelet therapy was excluded from participation in the present study.

Outcome measures and variables

The main endpoint of the present study was early (7-day) bleeding, which was classified as either minor (managed with direct compression, dressing replacement, or bedside suturing) or major (necessitating surgical exploration in the operating room, urgent therapeutic bronchoscopy for airway obstruction, a drop in hemoglobin of ≥ 2 g/dL, or transfusion of ≥ 2 units of packed red blood cells) [31, 32]. Additional outcomes assessed included PDT-associated mortality and 7-day, 30-day, and 1-year all-cause mortality.

Demographic and clinical information was collected from the patients' electronic health records, including age, sex, body mass index (BMI), Charlson Comorbidity Index, primary admission diagnosis, length of mechanical ventilation before tracheostomy, periprocedural antiplatelet use, platelet count, partial thromboplastin time (PTT), and international normalized ratio (INR) measured within 24–48 h before the procedure. Tracheostomy-related mortality, along with 7-day, 30-day, and 1-year all-cause mortality rates, was also recorded. The Charlson Comorbidity Index is a validated instrument for estimating mortality risk based on the overall burden of comorbidities. Individual conditions receive weighted points reflecting their prognostic significance, and the summed score indicates the combined impact of coexisting diseases. Elevated scores correlate with poorer prognosis and higher short- and long-term mortality [33].

Chart abstraction was performed using standard approaches recommended for retrospective analyses [34]. Trained abstractors who understood the study aims and hypothesis independently examined all medical records with the aid of a structured data collection sheet. A uniform extraction instrument was used to obtain relevant information from the charts systematically. Three abstractors collected the predictor variables, while another investigator documented the outcome measures. Reporting of the study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [35].

Statistical analysis

Categorical data were expressed as counts and percentages, whereas continuous variables were summarized as medians accompanied by interquartile ranges (IQR). Comparisons of continuous variables were performed with the Mann–Whitney U test, and categorical variables were analyzed using the $\chi 2$ test. Statistical significance was defined as a p-value below 0.05. All available cases within the study period from the

institutional databases were included. Missing values were handled by listwise deletion. To balance baseline differences between groups, propensity score matching was applied, adjusting for admission diagnosis, Charlson comorbidity index, and platelet count. The caliper width was set at 0.2 times the pooled standard deviation of the logit of the propensity score. All statistical analyses were carried out with IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA, 2019).

Results and Discussion

Throughout the study period, 1911 patients underwent tracheostomy because of prolonged mechanical ventilation. Of these, 225 patients (11.8%) were considered unsuitable for PDT owing to unfavorable neck anatomy noted on preliminary clinical assessment, including thick short necks, morbid obesity, cervical tumors, or goiter. These individuals received an open surgical tracheostomy. An additional 59 patients (3.1%) were excluded because they were on ongoing dual antiplatelet therapy. Ultimately, 1627 patients were analyzed, consisting of 65 individuals (4.0%) with active hematologic malignancy (HM) and 1562 patients (96.0%) in the control group **(Figure 1)**.

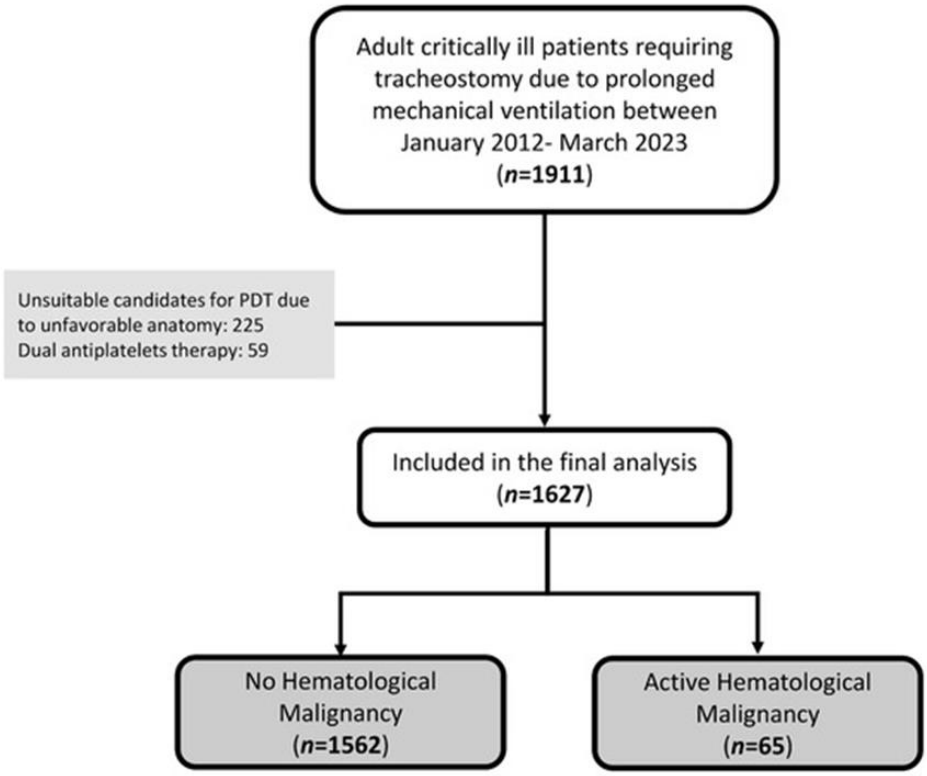

Figure 1. Study flow chart.

The spectrum of hematologic malignancies observed among the included patients is presented in **Table 1**.

Table 1. Types of hematological malignancy included in the study (n = 65), grouped by survival rates according to the Hematological Malignancies Research Network [8].

Prognostic category	Number of patients (%)
Favorable prognosis (5-year survival exceeding 70%)	15 (23.1%)
Intermediate prognosis (5-year survival between 30% and 70%)	32 (49.2%)
Unfavorable prognosis (5-year survival below 30%)	18 (27.7%)

Patients from both cohorts displayed broadly comparable baseline features. However, individuals with hematologic malignancy (HM) demonstrated substantially higher Charlson comorbidity index values (8.0, IQR 5.0–11.3 versus 5.0, IQR 2.0–7.0, $P < 0.001$) along with a markedly increased rate of thrombocytopenia (platelet count below 100,000/mcL) (49.2% versus 5.0%, $P < 0.001$). The distribution of admission diagnoses also varied noticeably between the groups **(Table 2)**. Only one patient in the hematological malignancy group required fresh frozen plasma (FFP) transfusion before the procedure. Across both groups, the majority of tracheostomies were performed late (at least 10 days after commencing invasive mechanical ventilation). Early tracheostomy occurred in 26.2% of HM patients and 28.0% of patients without hematologic disease ($P = 0.74$).

Table 2. Clinical and laboratory characteristics of the study cohort (n = 1627).

Variable	P-value	Active hematologic malignancy (n = 65)	No hematologic malignancy (n = 1562)
Age (years), median (IQR)	0.97	64.9 (55.9–70.1)	64.1 (49.2–74.0)
Male sex, n (%)	0.37	40 (61.5%)	1045 (66.9%)
Charlson comorbidity index, median (IQR)[a]	< 0.001	8.0 (5.0–11.3)	5.0 (2.0–7.0)
Primary reason for admission			
Medical cases, n (%)	< 0.001	41 (63.1%)	618 (39.6%)
Neurological cases, n (%)		5 (7.7%)	254 (16.3%)
Surgical cases, n (%)		4 (6.2%)	103 (6.6%)
Trauma-related cases, n (%)		2 (3.1%)	400 (25.6%)
Other causes, n (%)		13 (20.0%)	186 (11.9%)
Body mass index (kg/m²), median (IQR)	0.07	26.0 (22.00–29.19)	26.0 (23.11–30.75)
Duration of mechanical ventilation before tracheostomy, median (IQR)[b]	0.26	12.0 (9.0–15.0)	12.0 (9.0–17.0)
Early tracheostomy (<10 days of ventilation before PDT), n (%)	0.74	17 (26.2%)	438 (28.0%)
Aspirin use within 5 days before procedure, n (%)	0.32	6 (9.2%)	211 (13.5%)
Clopidogrel use within 5 days before procedure, n (%)	0.32	0 (0.0%)	23 (1.5%)
Platelet count (K/mcL), median (IQR)	< 0.001	100.0 (50.8–242.3)	282.0 (197.0–402.0)
Thrombocytopenia, n (%)[c]	< 0.001	32 (49.2%)	78 (5.0%)
INR, median (IQR)	0.88	1.07 (1.01–1.19)	1.07 (0.99–1.16)
aPTT (seconds), median (IQR)	0.38	27.7 (25.5–31.1)	28.7 (26.1–31.5)
Intraoperative complications, n (%)	0.32	0 (0.0%)	23 (1.5%)
Early bleeding events			
Minor bleeding, n (%)	0.29	5 (7.7%)	75 (4.8%)
Major bleeding, n (%)	0.65	0 (0.0%)	5 (0.3%)
Late bleeding, n (%)	0.68	0 (0.0%)	4 (0.3%)
PDT-related mortality, n (%)	0.33	1 (1.5%)	9 (0.6%)
7-day all-cause mortality, n (%)	< 0.001	13 (20.0%)	85 (5.4%)
30-day all-cause mortality, n (%)	< 0.001	32 (49.2%)	363 (23.3%)
1-year all-cause mortality, n (%)	< 0.001	48 (73.8%)	765 (49.0%)

A) The Charlson comorbidity index was missing in 10 patients (0.6%) in the control group. B) Mechanical ventilation duration was missing in 22 patients (1.4%) in the control group and 1 patient in the active hematological malignancy group (1.5%). C) Thrombocytopenia was defined as a platelet count < 100 K/mcL. Abbreviations: BMI = Body Mass Index; INR = International Normalized Ratio; PTT = Activated Partial Thromboplastin Time; PDT = Percutaneous Dilatational Tracheostomy. Statistically significant values ($P \leq 0.05$) are given in bold and italics.

Within the HM group, five patients (7.7%) developed early bleeding, and all episodes were minor in severity. In the control group, 80 bleeding events (5.1%) were recorded, of which 75 were minor, and 5 were major ($P = 0.36$). PDT-related mortality occurred in a single case in the HM group (1.5%), compared with 9 cases (0.6%) in the control group ($P = 0.33$). Nevertheless, mortality at 1 week, 30 days, and 1 year was significantly elevated among patients with HM.

After adjustment via propensity score matching for admission diagnosis, Charlson comorbidity index, and platelet count, the only significant difference that persisted was a higher 1-week mortality rate in the hematological disease group (23.4% versus 4.3%, $P = 0.007$). Bleeding complication rates and 1-year mortality remained comparable between the matched groups **(Table 3)**.

Table 3. Clinical and laboratory characteristics of the matched cohort.

Variable	P-value	Active hematologic malignancy (n = 47)	No hematologic malignancy (n = 47)
Age (years), median (IQR)	0.89	66.2 (58.8–71.9)	65.1 (59.7–72.3)
Male sex, n (%)	0.54	26 (55.3%)	23 (48.9%)
Charlson comorbidity score, median (IQR)	0.58	7.0 (6.0–8.0)	7.0 (5.0–9.0)
Reason for admission			
Medical cases, n (%)	1.00	32 (68.1%)	32 (68.1%)
Neurological cases, n (%)		4 (8.5%)	4 (8.5%)
Surgical cases, n (%)		2 (4.3%)	2 (4.3%)
Trauma-related cases, n (%)		1 (2.1%)	1 (2.1%)
Other diagnoses, n (%)		8 (17.0%)	8 (17.0%)
Body mass index (kg/m²), median (IQR)	0.58	25.9 (22.9–29.4)	25.0 (23.5–31.0)
Duration of mechanical ventilation before tracheostomy, median (IQR)	0.01	12.0 (10.0–15.0)	15.0 (10.3–22.8)
Aspirin use within 5 days before procedure, n (%)	0.08	4 (8.5%)	10 (21.3%)
Clopidogrel use within 5 days before procedure, n (%)	1.00	0 (0.0%)	0 (0.0%)
Platelet count (mcL), median (IQR)	0.34	121 (81.0–244.8)	188.0 (73.0–268.3)
Thrombocytopenia, n (%)	1.00	19 (40.4%)	19 (40.4%)
INR, median (IQR)	0.31	1.07 (1.02–1.20)	1.05 (0.97–1.13)
aPTT (seconds), median (IQR)	0.16	29.3 (26.0–31.8)	27.9 (24.2–30.5)
Intraoperative complications, n (%)	0.32	0 (0.0%)	1 (2.1%)
Early bleeding events			
Minor bleeding, n (%)	0.69	3 (6.4%)	4 (8.5%)
Major bleeding, n (%)	1.00	0 (0.0%)	0 (0.0%)
Late bleeding, n (%)	1.00	0 (0.0%)	0 (0.0%)
PDT-related mortality, n (%)	1.00	0 (0.0%)	0 (0.0%)
7-day all-cause mortality, n (%)	0.007	11 (23.4%)	2 (4.3%)
30-day all-cause mortality, n (%)	0.06	23 (48.9%)	14 (29.8%)
1-year all-cause mortality, n (%)	0.46	35 (74.5%)	38 (80.9%)

Abbreviations: BMI = Body Mass Index; INR = International Normalized Ratio; PTT = Activated Partial Thromboplastin Time; PDT = Percutaneous Dilatational Tracheostomy. Statistically significant values ($P < 0.05$) are given in bold and italics.

This study demonstrated that percutaneous dilatational tracheostomy (PDT) can be performed safely in critically ill patients with hematologic malignancies (HM) who require extended mechanical ventilation. After adjustment for comorbidity burden and other confounding factors, PDT was not associated with an increased risk of early bleeding in this patient population. However, individuals with HM showed elevated short-term mortality at both 7 days and 30 days, although these deaths were not directly related to the tracheostomy procedure itself. No meaningful difference in 1-year all-cause mortality was observed between the groups.

Patients with HM who are admitted to the intensive care unit generally face high mortality, and the onset of respiratory failure necessitating invasive mechanical ventilation further worsens their prognosis [36]. Managing respiratory failure in this distinct population remains particularly difficult. Successful intensive care support as a bridge to potentially curative cancer therapy demands coordinated efforts among hematologists, intensivists, pulmonologists, infectious disease experts, clinical microbiologists, and additional multidisciplinary team members [11]. A large international study by Bris *et al*. [37] documented a 64.4% mortality rate at 90 days among patients with HM admitted to the ICU for acute respiratory failure. The clinical trajectory of these severely ill individuals is frequently complicated by numerous issues, such as frequent infections and sepsis, metabolic abnormalities, and an elevated likelihood of both hemorrhagic and thrombotic complications [27].

Furthermore, these patients encounter higher rates of adverse events and increased mortality after a wide range of surgical procedures, even relatively minor ones [38-40]. Forrester *et al*. [38] reported a standardized mortality ratio of 2.9 (IQR 2.2–3.8) for patients with HM undergoing most general surgical procedures. In a separate investigation by Nguyen *et al*. [39], individuals with HM undergoing cardiac surgery experienced markedly higher postoperative complication rates, including greater

requirements for blood product transfusions, respiratory issues, acute kidney injury, and extended durations of ICU and hospital stay. Thirty-day mortality was also higher, although not statistically significant in that analysis [39, 41, 42].

Some perioperative complications in this population may stem from immunosuppression related to the underlying disease or its treatment; however, acute procedural complications are most often driven by the heightened bleeding risk that is characteristic of these patients [43]. While thrombocytopenia or extended prothrombin time can account for bleeding diathesis in certain cases, dependable laboratory markers for precisely evaluating bleeding risk in critically ill patients with HM remain unavailable [43]. Vigneron *et al*. [44] observed that 10.8% of 1012 critically ill hematologic patients experienced severe bleeding episodes, graded 3 or 4 according to World Health Organization (WHO) criteria. Their analysis was restricted to hemorrhages that developed at least 24 hours after ICU admission. Among these severe events, 57.8% were classified as grade 4, representing potentially fatal bleeding. Patients who developed bleeding required more intensive supportive care, including prolonged mechanical ventilation, vasopressor support, renal replacement therapy, and higher transfusion volumes, and they also experienced significantly increased ICU mortality and longer ICU lengths of stay [44].

Data regarding the safety and results of tracheostomy in patients with cancer, especially those with HM, remain scarce. Angelberger *et al*. [45] assessed the safety of both PDT and open surgical tracheostomy in immunocompromised individuals with hematological disorders, most of whom had low platelet counts. In their retrospective series of 84 patients (63 of whom received PDT), periprocedural complications arose in only three cases (4.6%), with no procedure-related deaths. Post-procedural bleeding occurred in two patients (3.2%), and bleeding events were more frequent after the open surgical approach. Kumar *et al*. [46] concluded that tracheostomy could be carried out safely even in critically ill cancer patients with substantial comorbidities, thrombocytopenia, and concurrent COVID-19.

Nevertheless, short-term mortality remained high in this cohort. Most participants had solid tumors, with only 36% diagnosed with HM. No major procedural complications or intra-procedural deaths were recorded. By six months, 70% of the patients had died [46]. Earlier research has indicated that PDT can be performed safely in other high-bleeding-risk critically ill populations, such as patients with liver cirrhosis or those on dual antiplatelet therapy [24, 25]. A small study involving 26 neutropenic patients similarly concluded that tracheostomy was a safe intervention [47].

Our investigation showed a remarkably low complication rate in patients with hematologic malignancies (HM) who underwent percutaneous dilatational tracheostomy (PDT). Only one periprocedural death occurred (1.5%), and early minor bleeding was documented in five cases (7.7%). Despite this, nearly 20% of the patients in this group died within one week after the intervention. Although one-year mortality remained elevated, it did not differ significantly from the rates seen in patients without HM. The extreme severity of the underlying critical illness most likely explains the elevated short-term mortality. Nevertheless, other potential contributors — such as suboptimal timing of the tracheostomy or an elevated susceptibility to post-procedural infections — merit careful consideration and further study.

Patients with hematologic malignancies in this series underwent tracheostomy after a median of 12 days on invasive mechanical ventilation, and only 1/4 received the procedure early (generally defined in the literature as within 7–10 days of intubation). A substantial body of evidence indicates that performing tracheostomy earlier is associated with modestly reduced mortality, shorter ICU stays, decreased time on mechanical ventilation, and fewer pulmonary infections compared with delayed procedures [48, 49]. In addition, early tracheostomy enables patients to achieve key person-centered goals more rapidly, such as regaining speech, participating in out-of-bed mobilization, and resuming oral intake. These individuals also tend to require lower doses of sedative and analgesic medications [50]. Specific subgroups appear to gain particular benefit from an earlier approach, including those with severe traumatic brain injury, stroke, acute spinal cord trauma, multiple rib fractures, and possibly patients suffering from extensive polytrauma [41, 42, 51-53]. In a 1995 report by Blot *et al*. [54], tracheostomy performed within 48 hours of initiating mechanical ventilation in neutropenic patients showed a trend toward prolonged survival.

The ideal timing of tracheostomy has not been rigorously studied in patients with cancer or, more specifically, in those with hematologic malignancies. Because these individuals often face greater difficulty in being weaned from mechanical ventilation [19], we propose that earlier tracheostomy should be seriously considered in this population. Such an approach might permit a smoother tapering of continuous sedative and inotropic support used to manage hypotension. Several sedative agents (propofol, remifentanil, midazolam) and neuromuscular blocking drugs have been linked to immune suppression, prolonged cytokine release, micro-aspiration, disturbed gut motility, microvascular alterations, and increased infection susceptibility [55]. By facilitating earlier tracheostomy, clinicians may accelerate weaning, lower the risk of ventilator-associated pneumonia and systemic infections,

promote faster awakening and mobility, simplify daily nursing care, and thereby improve the prospects for timely rehabilitation and hospital discharge [56].

Our study has several important limitations. First, the retrospective design carries intrinsic methodological constraints. Second, the limited number of patients in the HM cohort may have introduced statistical bias. Third, the evaluation was restricted to bleeding complications and did not examine other clinically relevant adverse events, including ventilator-associated pneumonia or infections at the tracheostomy stoma.

Conclusion

In conclusion, percutaneous dilatational tracheostomy is not associated with increased rates of early bleeding or procedure-related mortality among critically ill patients with hematologic malignancies. However, approximately one in four of these patients can be expected to die within the first week after the procedure. Larger, well-designed studies are needed to confirm these observations and to identify the specific factors driving early mortality in this vulnerable group. In particular, the influence of tracheostomy timing on clinical outcomes in patients with hematologic malignancies warrants further investigation.

Acknowledgments: None

Conflict of interest: None

Financial support: None

Ethics statement: The institutional review board of the Rambam Healthcare Campus (0143-21-RMB) approved this study on 20 May 2021. Informed consent was waived.

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