



Evaluation of *Acinetobacter baumannii* Infections and Skin Colonization in the Neonatal Intensive Care Unit

Yenidoğan Yoğun Bakım Ünitesinde *Acinetobacter baumannii* Enfeksiyonları ve Cilt Kolonizasyonunun Değerlendirilmesi

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Abstract

Objective: *Acinetobacter baumannii* is a gram-negative, aerobic coccobacillus found in water and soil. It causes soft tissue infections, urinary tract infections, pneumonia, bacteremia, and meningitis. *A. baumannii* is a pathogen of concern due to the healthcare-associated infections it causes and limited therapeutic options. This study aims to evaluate the course of *A. baumannii* infections and skin colonization detected during active surveillance, causative antibiotic susceptibilities, and prognostic risk factors in the neonatal intensive care unit.

Material and Methods: Demographic, clinical, and laboratory findings of the patients who were hospitalized in Erciyes University, Faculty of Medicine, Neonatal Intensive Care Unit between 2018 and 2021 and in whom *A. baumannii* was grown in the sterile field, wound or skin swab cultures during the active surveillance period were evaluated retrospectively.

Results: Within four years, *A. baumannii* was detected in cultures in 103 cases. 61% (61/103) of the cases were male. Growth was observed in 82 cases, including blood (58.3%) in 60, tracheal aspirate in 14 (13.6%), urine in three (2.9%), one each in the pleural, peritoneal, and cerebrospinal fluids, and one patient in the wound culture. During the active surveillance period, skin colonization was detected in 22 cases (21.4%), while invasive disease developed in one of these cases (1/22, 4.5%). While all agents were susceptible to colistin and resistant to beta-lactams and carbapenems, only one agent was sensitive to aminoglycosides. 77.7% of the cases were premature, and 27% had an underlying disease. Bacterial co-infection was observed in 28.2% of the cases. There was no significant difference in terms of birth weight and prematurity between

Öz

Giriş: *Acinetobacter baumannii*, su ve toprakta bulunan gram-negatif, aerobik bir kokobasildir. Yumuşak doku enfeksiyonları, idrar yolu enfeksiyonu, pnömoni, bakteriyemi, menenjitte neden olmaktadır. *A. baumannii* sebep olduğu sağlık hizmeti ilişkili enfeksiyonlar ve sınırlı terapötik seçenekleriyle endişe kaynağı olan bir patojendir. Bu çalışmanın amacı yenidoğan yoğun bakım ünitesinde *A. baumannii* enfeksiyonlarının ve aktif süreyans döneminde tespit edilen cilt kolonizasyonlarının seyri, etken antibiyotik duyarlılıkları ve prognostik risk faktörlerini değerlendirmektir.

Gereç ve Yöntemler: Erciyes Üniversitesi Tıp Fakültesi Yenidoğan Yoğun Bakım Ünitesine, 2018-2021 yıllarında yatırılmış ve yatış sürecinde steril alan, yara veya aktif süreyans döneminde cilt sürüntü kültürlerinde *A. baumannii* üreyen olguların demografik, klinik ve laboratuvar bulguları retrospektif olarak değerlendirilmiştir.

Bulgular: Dört yıl içerisinde, 103 olguda kültürlerde *A. baumannii* tespit edildi. Olguların %61 (61/103)'i erkekti. Altmışında kan (%58.3), on dördünde trakeal aspirat (%13.6), üçünde idrar (%2.9), birer adet pleural, periton ve beyin omurilik sıvılarında ve bir olgunun da yara kültüründe olmak üzere 82 olguda üreme görüldü. Aktif süreyans döneminde 22 olguda (%21.4) cilt kolonizasyonu tespit edilirken, bu olguların birinde invaziv hastalık gelişti (1/22, %4.5). Tüm etkenler kolistine duyarlı, beta-laktamlara ve karbapenemlere dirençliken, sadece bir etken aminoglikozitlere duyarlıydı. Olguların %77.7'si prematür ve %27'sinde altta yatan bir hastalık mevcuttu. Olguların %28.2'sinde bakteriyel ko-enfeksiyon görüldü. Kolonizasyon ile enfeksiyon gelişen gruplar arasında doğum ağırlığı ve prematürite açısından anlamlı fark yoktu. Mortalite,

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the groups with colonization and infection. Mortality was significantly higher in the infection group than in the colonization group (39% vs. 9.5%). In the infection group, low birth weight, small postnatal age, high procalcitonin, low platelet, high creatinine values on the first day of the treatment and following the seventh day, and low lymphocyte values on the third day of treatment were found to be associated with mortality. Gender, prematurity, concomitant diseases, and C-reactive protein values were not associated with mortality in the infection group.

Conclusion: *A. baumannii* infections cause high mortality in newborns. Although the transition rate from colonization to infection is low, cross-contamination within the unit should be prevented as much as possible due to the high infection mortality. Vascular catheters and TPN should be stopped as soon as possible. Monitoring acute kidney injury, procalcitonin, and absolute lymphocyte and platelet values in the follow-up of infected cases can provide clinicians with important information about prognosis.

Keywords: *Acinetobacter baumannii*, newborn, epidemic, sepsis, colonization

enfeksiyon grubunda kolonizasyon grubuna göre anlamlı olarak fazlaydı (%39 vs %9.5). Enfeksiyon grubunda, düşük doğum ağırlığı, küçük postnatal yaş, prokalsitonin yüksekliği, trombosit düşüklüğü, kültür pozitifliği ve izleyen yedinci gündeki kreatin yüksekliği, ve tedavinin üçüncü gününde de lenfosit değerlerinin düşüklüğünün mortaliteyle ilişkili olduğu tespit edildi. Cinsiyet, prematürite, eşlik eden hastalıklar ve C-reaktif protein değerlerinin enfeksiyon grubunda mortalite ile ilişkisi görülmedi.

Sonuç: *A. baumannii* enfeksiyonları yenidoğanlarda yüksek mortaliteye neden olmaktadır. Kolonizasyondan enfeksiyona geçiş düşük oranda olmakla birlikte, enfeksiyonun yüksek mortalitesi nedeniyle ünite içerisinde çarpaz bulaş mümkün olduğunca engellenmelidir. Vasküler kateter ve TPN kullanımı mümkün olan en erken zamanda sonlandırılmaya çalışılmalıdır. Enfekte olguların takibinde akut böbrek hasarı, prokalsitonin, mutlak lenfosit ve trombosit değerlerinin izlenmesi klinisyene prognoz hakkında önemli bilgiler sağlayabilir.

Anahtar Kelimeler: *Acinetobacter baumannii*, yenidoğan, salgın, sepsis, kolonizasyon

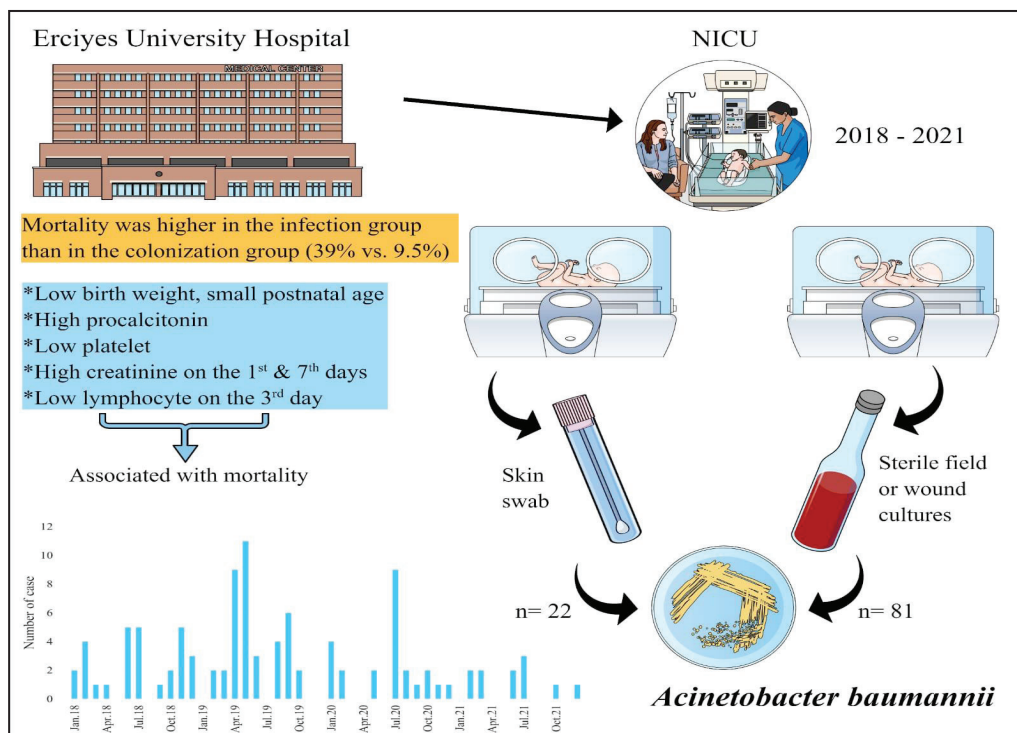
Introduction

Acinetobacter baumannii is a gram-negative, aerobic coccobacillus found in water and soil. It causes soft tissue infections, urinary tract infections, pneumonia, bacteremia, and meningitis (1). It is a cause for concern because of the healthcare-associated infections it causes and its limited therapeutic options. In developing countries, the most common gram-negative pathogens in neonatal sepsis are *Klebsiella* spp., *Escherichia coli*, and *A. baumannii*. Although it varies geographically, it is reported that the causative agent is *A.*

baumannii in newborns in 8-22% of blood culture-positive sepsis (1-3). In our study, we aimed to examine risk factors for *A. baumannii* infection and skin colonization in our neonatal intensive care unit (NICU), antibiotic susceptibility of isolated strains, course of infection, and possible prognostic features in clinical and laboratory terms.

Materials and Methods

Demographic, clinical, and laboratory findings of the patients hospitalized in Erciyes University Faculty of Medicine, Neonatal Intensive Care Unit (NICU) between 2018 and 2021



Graphical abstract of the study.

and whose cultures grew *A. baumannii* during the hospitalization were evaluated. Cultures of sterile field (blood, urine, cerebrospinal fluid, endotracheal aspirate, pleural and peritoneal fluid), wound culture, or skin swab cultures during hospitalization were evaluated. Between April and August 2019, active surveillance was performed for *Acinetobacter* colonization by taking swab cultures from hospitalized patients weekly. Swab cultures were taken by rubbing the swab into the armpit, chest, groin, and perianal regions, starting from the neck region, respectively. Swab cultures were inoculated on MacConkey and blood agars. Liquid culture samples were taken into Bactec Ped Plus bottles and studied on the BACTEC 9240 (Becton Dickinson, USA) device. Antibiotic susceptibility tests were performed on the growing specimens with the automatic Vitek 2 Compact (bioMérieux, France) system. Co-infection was defined as the detection of another bacteria in sterile field cultures within ± 7 days of the first *Acinetobacter* isolated culture date. The patients' clinical information and laboratory results were collected retrospectively from the hospital records. Acute kidney injury was evaluated according to the widely accepted classification of neonatal acute kidney injury proposed by Jetton JG and Askenazi DJ (4). Mortality due to infection was accepted as all deaths within the first 14 days or deaths due to complications directly related to the infection between the 14th and 30th days after the culture positivity. The data were analyzed by anonymizing. The study was approved by the Erciyes University Clinical Research Ethics Committee (Decision No: 2022/454, Date: 08.06.2022).

Statistical Analysis

Statistical data analysis was performed using IBM SPSS for Windows (version 25 for Windows, IBM Corporation, Armonk, New York, United States). In the descriptive statistics of the data, mean \pm standard deviation for the normally distributed variables and median (interquartile range) values for the non-normally distributed variables were used. Qualitative data were analyzed with the chi-square test, while quantitative data were analyzed with the Student's t-test or Mann-Whitney U

test as appropriate. $p < 0.05$ was accepted for statistical significance.

Results

A. baumannii was detected in at least one culture of a total of 103 cases during the four years of the study. The distribution of cases over time is shown in Figure 1. When the cultural regions are examined; cultures of 82 patients, including 61 blood (58.3%), 15 tracheal aspirates (13.6%), three urine (2.9%), one pleural, peritoneal, and cerebrospinal fluid, and one wound culture, were positive. During the active surveillance period, skin colonization was detected in 22 cases (21.4%), while invasive disease developed in one of these cases (1/22, 4.5%). Growth was observed in the blood culture of a case who developed an invasive infection after colonization. Bacterial co-infection developed in 24.3% (25/103) of the cases. The most common accompanying bacterial infection was *Enterococcus faecalis* bacteremia (10/103, 9.7%). All of the isolated *A. baumannii* strains were susceptible to colistin, resistant to beta-lactams and carbapenems, and only one strain was sensitive to aminoglycosides. Microbiological data of the cases are shown in Table 1.

Of the cases, 61% (61/103) were male, 77.7% (80/103) were premature, and 27% (28/103) had an underlying disease. The median age at which culture positivity was detected was nine days. In cases with *Acinetobacter* infection, the presence of vascular catheters and total parenteral nutrition was significantly higher than in the colonization group (98.8% vs. 81%, $p = 0.006$ vs. 91.5% vs. 66.7%, $p = 0.008$). Necrotizing enterocolitis was seen in 10.7% (11/103) of the cases. 33% (34/103) of the cases died. Mortality was significantly higher in the infection group than in the colonization group (39% vs. 9.5%, $p = 0.01$). The rates of development of necrotizing enterocolitis, need for mechanical ventilation, and long-term antibiotic use did not differ between infection and colonization groups. Demographic and clinical characteristics of the cases in infection and colonization groups are shown in Table 2 comparatively.

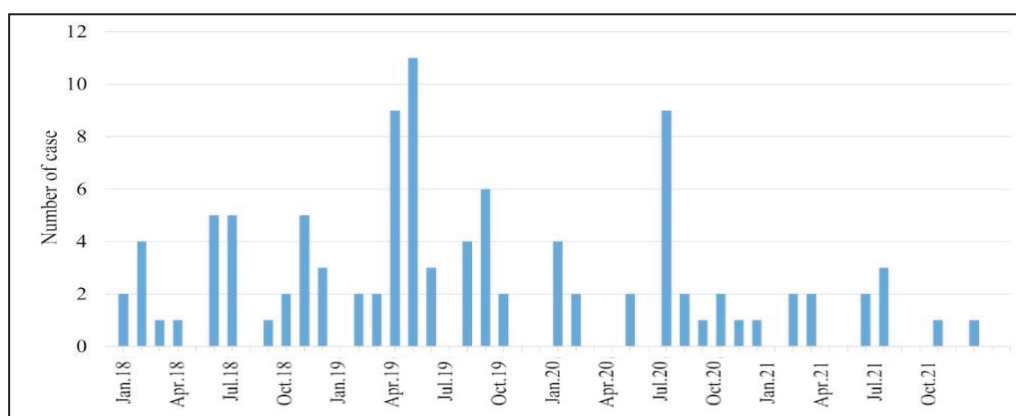


Figure 1. Temporal distribution of the cases with *Acinetobacter baumannii*.

Table 1. Microbiological findings of all cases

Variable	All cases (n= 103)
Culture site*, n (%)	
Blood	61 (59.2)
Tracheal aspirate	15 (14.6)
Urine	3 (2.9)
Pleural fluid	1 (1)
Peritoneal fluid	1 (1)
Cerebro spinal fluid	1 (1)
Wound swab	1 (1)
Skin swab**	22 (21.4)
Antibiotic susceptibility, n (%)	
Beta-lactam	0 (0)
Carbapenem	0 (0)
Amikacin	1 (1)
Colistin	103 (100)
Presence of other microorganisms, n (%)	
Microorganism detected	25 (24.3)
<i>Enterococcus faecalis</i>	10 (9.7)
<i>Pseudomonas</i> spp.	5 (4.9)
<i>Escherichia coli</i>	3 (2.9)
<i>Candida</i> spp.	3 (2.9)
<i>Staphylococcus aureus</i>	2 (1.9)
<i>Klebsiella</i> spp.	1 (1.0)
<i>Serratia</i> spp.	1 (1.0)
* There was positivity in more than one area in one case.	
** In the follow-up of a case with a positive skin swab, there was also growth in the blood culture.	

When the nonsurvivor and survivor cases were compared among the infected group; In the cases who died, the birth weight was lower (median 960 g vs. 1685 g, $p= 0.04$), the postnatal age was smaller (six days vs. 13 days, $p< 0.001$), the presence of necrotizing enterocolitis was less frequent (0% vs. 18%, $p= 0.01$), and the rate of long-term antibiotic use beforehand was also lower (46.9% vs. 81.6, $p= 0.002$) (Table 3). When the laboratory data of the nonsurvivor and surviving cases in the same group were compared, an increase in creatinine was observed in the patients who died on the 0th, 7th, and 14th days. Acute kidney injury was seen at a higher rate in the nonsurvivor cases (71.9% vs. 24%, $p< 0.001$), while there was no significant difference in the need for renal replacement. Procalcitonin was higher on day 0, platelet count was higher on days 0 and 3, and total leukocyte and absolute lymphocyte counts were lower on day three in deceased cases compared to survivors (Table 4). Gender, prematurity, presence of underlying disease, absolute neutrophil count, and C-reactive protein (CRP) values were not associated with mortality in the infection group.

Discussion

Our study is one of the largest *Acinetobacter* spp. infection case series in the literature reported in the NICU. It is one of the few studies evaluating colonization and infection together also. The microbiota of newborns is shaped by perinatal transfer, directly affected by the mother's genital system, breast milk, contaminated environmental surfaces, interventions, and human contact (hands, nasal carrier, i.e.). In NICU, the risk of being colonized with resistant microorganisms in the hospital environment increases. Gastrointestinal and skin colonization has been associated with an increased risk of bloodstream infections with pathogenic bacteria, particularly gram-negative bacteria. There are limited studies in the literature on the asymptomatic colonization of newborns admitted to the NICU. A study conducted in the NICU in Thailand showed that 52% of hospitalized cases were colonized with a bacteria producing expanded beta-lactamase, while 64% were colonized with carbapenem-resistant bacteria (5). In a study conducted in a tertiary NICU in India, 155 infants were followed, and *A. baumannii* colonization was demonstrated in 12.2% (19/155) of them. While the rate of bloodstream infection due to *A. baumannii* was 21% in colonized infants, this rate was 5.8% in non-colonized infants (6). In our study, we observed a much lower bloodstream infection rate (4.5%) in colonized infants. In a study conducted in Estonia in 2011, in the follow-up of 278 newborns, the colonization on the mucosal surfaces by *Klebsiella* spp., *E. coli*, *Stenotrophomonas* spp., and *Pseudomonas* spp. was related to a higher risk for invasive diseases (7). In the same study, a similar risk was not found for *Acinetobacter* spp. Many factors, such as geographical differences, and characteristics of the cases followed, will affect the results of colonization-infection studies. In a systematic review and meta-analysis, Folgori et al. found that the bloodstream infection rate with gram-negative bacteria in colonized infants was 7.9%, while the same rate was 2.4% in non-colonized infants (8). Currently, routine colonization screening for gram-negative bacteria is not recommended in NICUs. However, considering the studies, colonization screening for causative bacteria can be evaluated by making unit-based evaluations during local epidemics. Cohorting colonized infants through screening may break the chain of transmission within the unit, contributing to closer follow-up of these infants and changing empirical antibiotic choices.

In our study, *A. baumannii* strains were sensitive only to colistin and resistant to aminoglycosides. Antimicrobial resistance is one of the most critical problems of the future, and *A. baumannii* has been labeled by the World Health Organization as the leading critical pathogen globally within the scope of a widely drug-resistant strain (9). It is known that the most significant factor in the development of resistance is the inappropriate use of antibiotics. Bacterial co-infection was seen at a high rate of 24.3% in our case series. There was no significant difference in the colonized and infection groups.

Table 2. Demographic and clinical features of the cases

Variable	All cases (n= 103)	Infection (n= 82)	Colonization* (n= 21)	P
Gender, male, n (%)	61 (61)	50 (61)	11 (52.4)	0.61
Birthplace, out of our center, n (%)	16 (15.5)	15 (18.3)	1 (4.8)	0.18
Gestational age, median week (min-max)	31 (23-40)	31 (23-40)	32 (25-39)	0.84
Term birth, n (%)	23 (22.3)	18 (22)	5 (23.8)	0.53
Birth weight, median gram (min-max)	1530 (530-4600)	1605 (530-4600)	1520 (530-3200)	0.99
Postnatal age at which culture positivity was detected, median days (min-max)	9 (1-250)	9 (1-250)	7 (2-70)	0.50
Underlying disease, n (%)				0.25
None	75 (72.8)	58 (70.7)	17 (81)	
Yes	28 (27.2)	24 (29.3)	4 (19)	
Cardiovascular system diseases	8 (7.7)	7	1 (4.8)	
Genitourinary diseases	4 (3.9)	4 (4.8)	0	
Diaphragmatic hernia	3 (2.9)	3 (3.7)	0	
Hydrocephaly	3 (2.9)	3 (3.7)	0	
Metabolic diseases	2 (1.9)	2 (2.4)	0	
Meningomyelocele	2 (1.9)	0	2 (9.5)	
Esophageal atresia	2 (1.9)	1 (1.2)	1 (4.8)	
Anal atresia	1 (1)	1 (1.2)	0	
Omphalocele	1 (1)	1 (1.2)	0	
Harlequin baby	1 (1)	1 (1.2)	0	
Corpus callosum agenesis	1 (1)	1 (1.2)	0	
Presence of central venous catheter, n (%)	98 (95.1)	81 (98.8)	17 (81)	0.006
Total parenteral nutrition support, n (%)	89 (86.4)	75 (91.5)	14 (66.7)	0.008
Necrotizan enterocolitis, n (%)	11 (10.7)	9 (11)	2 (9.5)	0.60
Mechanical ventilator support, n (%)	87 (84.5)	72 (87.8)	15 (71.4)	0.08
History of long-term use of antibiotics, n (%)	68 (66)	55 (67.9)	13 (61.9)	0.61
Presence of bacterial co-infection, n (%)	25 (24.3)	22 (26.8)	3 (14.3)	0.18
Mortality**, n (%)	34 (33)	32 (39)	2 (9.5)	0.01

* A case with growth in the skin swab also had growth in the blood culture in the follow-up, and the case was included in the infection group in the analyses.

** All deaths occurring within the first 14 days after culture positivity or death due to an infection-related complication between the 14th and 30th days were considered infection-related mortality.

It should be kept in mind that there may be more than one factor in the treatment of the cases, and this issue should be considered when arranging antibiotic therapy.

In the literature, prematurity and low birth weight are the leading risk factors for infection in NICU outbreaks associated with *A. baumannii* (2,7,10). Gajic et al. found the risk factors for *Acinetobacter* spp. infection in the NICU as low gestational age, low Apgar score, vaginal delivery, and mechanical ventilation (11). In the same study, four of 13 cases died (30.8% mortality) in the epidemic they examined, and the source could not be found. Mahic et al., in their study in India, also showed that *A. baumannii* sepsis occurs in postnatally smaller infants compared to other bacterial agents (1). In a series of 40 cases reported from China, prematurity, very low birth weight, prolonged

intubation, use of a central venous catheter (CVC), and long-term use of total parenteral nutrition (TPN) or lipid solution were more common in those with *Acinetobacter* infection (12). Similarly, in a study conducted in Taiwan, infants with *A. baumannii* were more likely to use CVC and TPN than uninfected controls and newborns with *E. coli* or *Klebsiella* spp. bacteremia (13). Unlike the literature, we compared colonized and infected infants in our study and found that only CVC use and total parenteral nutrition among the risk factors for *A. baumannii* infection were higher in infected infants. Skin colonization at the catheter exit site is strongly associated with catheter colonization and catheter-related sepsis (14). We think that TPN support is significant in our study because it increases the use of catheters and is indirectly related to the severity of the general condition of the case.

Table 3. Examination of demographic and clinical findings in infection-related mortality

Variable	Infection-related mortality		P
	Yes (n= 32)	No (n= 50)	
Gender, male, n (%)	17 (53.1)	33 (66)	0.25
Birthplace, out of our center, n (%)	4 (12.5)	11 (22)	0.38
Gestational age, median week (min-max)	29.5 (23-40)	32 (25-40)	0.28
Term birth, n (%)	7 (21.9)	11 (22)	1.00
Birth weight, median gram (min-max)	960 (530-4600)	1685 (600-3850)	0.04
Presence of central venous catheter, n (%)	6 (1-127)	13 (3-250)	<0.001
Total parenteral nutrition support, n (%)	10 (31.3)	14 (28)	0.80
Necrotizan enterocolitis, n (%)	31 (96.9)	50 (100)	0.39
Mechanical ventilator support, n (%)	30 (93.8)	45 (90)	0.70
History of long-term use of antibiotics, n (%)	0 (0)	9 (18)	0.01
Presence of bacterial co-infection, n (%)	31 (96.9)	41 (82)	0.08
Presence of central venous catheter, n (%)	10 (31.3)	12 (24)	0.61
Presence of long-term use of antibiotics,n (%)	15 (46.9)	40 (81.6)	0.002

Table 4. Examination of laboratory findings in infection-related mortality

Variable	Infection-related mortality		p
	Yes (n= 32)	No (n= 50)	
Creatinin, median value (mg/dL)			
Treatment Day 0	1.19	0.44	<0.001
Day 7	1.72	0.37	0.001
Day 14	1.54	0.35	0.03
Acute renal injury, n (%)	23 (71.9)	12 (24)	<0.001
Renal replacement need, n (%)	4 (12.5)	3 (6)	0.42
C-reactive protein, median value (mg/dL)			
Day 0	58.34	52.99	0.76
Day 3	91.04	36.26	0.71
Procalcitonin, median value (ng/dL)			
Day 0	17.07	1.2	0.02
Total leukocyte, median value (cell/mm ³)			
Day 0	12.235	15.105	0.12
Day 3	10.100	14.210	0.03
Absolute neutrophil count, median value (cell/mm ³)			
Day 0	5340	7750	0.14
Day 3	8700	8125	0.71
Absolute lymphocyte count, median value (cell/mm ³)			
Day 0	1455	2925	0.005
Day 3	1950	3820	<0.001
Thrombocyte count, median value (cell/mm ³)			
Day 0	93.500	235.500	0.004
Day 3	78.000	254.500	<0.001

In the literature, mortality due to *A. baumannii* infection in newborns has been reported in the range of 13.9-83% (1,2,6,11). Mortality was reported at 55.5% in a NICU epidemic, with 18 cases reported from Türkiye (10). In our study, we also found a high infection-related mortality rate (39%). Although the transition from colonization to infection is at a low rate, its high mortality and widespread antibiotic resistance make *A. baumannii* one of the most dangerous nosocomial infections in NICUs. Mortality was higher in infants with lower birth weight and younger postnatal age in our infected cases. Intestinal bacterial translocation due to NEC increases mortality by increasing the risk of bacterial co-infection and sepsis. In a series of 79 cases from India, the development of NEC due to *A. baumannii* infection was reported in five infants (6.4%) (15). In our study, NEC development was observed in the surviving cases. Similarly, prolonged antibiotic use was less common in patients who died. Those can be explained by the fact that the cases become infected and die in the early period.

In a retrospective study of 91 newborns with *A. baumannii* sepsis, mortality was 36.3%, and mortality was associated with septic shock (OR= 41.38), severe thrombocytopenia (<50.000/mm³, OR= 33.7), and inappropriate initial antibiotic therapy (OR= 10.05) (16). In the mentioned study, CRP and procalcitonin were not examined, and no relationship could be demonstrated with acute renal injury. In different studies in the literature, Apgar score (12), need for invasive mechanical ventilation (17), CVC (18), neutropenia (18,19), and acute renal injury (19,20) have been shown to increase mortality. In the laboratory parameters of our study, based on mortality, procalcitonin was more distinctive than CRP in determining the severity of the disease in the early period. The persistence of low absolute lymphocyte and platelet counts at the time of diagnosis and during follow-up may be a warning for more aggressive treatment in differentiating cases with high mortality risk. Acute renal injury appears to be associated with mortality at the diagnosis and the days following treatment. Renal damage can also occur due to septic shock or circulatory dysfunction. Although the need for renal replacement does not differ between the groups, the follow-up of acute kidney injury will guide the prognosis of the case.

In our study, clone analysis could not be performed on the strains by molecular method, so it is unknown how many different bacterial clones were encountered in four years. In the studies carried out under infection control measures throughout the process, no source of infection was found in our NICU. Cross-contamination within the unit is considered to be the primary source of spread. Apart from this, the limitations of our study include the fact that the concurrent medical treatments of the cases were not evaluated in detail,

and the late mortality and morbidity that occurred longer than 30 days were not examined. We think more detailed studies are necessary to reveal the prognostic values of the clinical and laboratory features associated with mortality in infected cases.

Conclusion

A. baumannii infections cause high mortality in newborns. Although the transition rate from colonization to infection is low, cross-contamination within the unit should be prevented as much as possible due to the high infection mortality. Vascular catheters and TPN should be stopped as soon as possible. Monitoring acute kidney injury, procalcitonin, and absolute lymphocyte and platelet values in the follow-up of infected cases can provide clinicians with important information about prognosis.

Ethics Committee Approval: The study was approved by the Erciyes University Clinical Research Ethics Committee (Decision No: 2022/454, Date: 08.06.2022).

Informed Consent: Informed consent was not obtained due to retrospective nature of the study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept- BŞÇ; Design- All of authors; Supervision-TG; Resource- BŞÇ, ST; Data Collection and/or Processing- ST; Analysis and/or Interpretation- All of authors; Literature Search - BŞÇ; Writing- BŞÇ; Critical Review- ST, TG.

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References

1. Mahich S, Angurana SK, Suthar R, Sundaram V, Munda VS, Gautam V. *Acinetobacter sepsis among out-born neonates admitted to neonatal unit in pediatric emergency of a tertiary care hospital in North India.* Indian J Pediatr 2021;88(2):127-33. [CrossRef]
2. Chaurasia S, Sivanandan S, Agarwal R, Ellis S, Sharland M, Sankar MJ. *Neonatal sepsis in South Asia: huge burden and spiralling antimicrobial resistance.* BMJ 2019;364:k5314. [CrossRef]
3. Souli M, Galani I, Giamarellou H. *Emergence of extensively drug-resistant and pandrug-resistant Gram-negative bacilli in Europe.* Euro Surveill 2008;13(47):19045. [CrossRef]
4. Jetton JG, Askenazi DJ. *Update on acute kidney injury in the neonate.* Curr Opin Pediatr 2012;24(2):191-6. [CrossRef]
5. Roberts T, Limmathurotsakul D, Turner P, Day NPJ, Vandepitte WP, Cooper BS. *Antimicrobial-resistant Gram-negative colonization in infants from a neonatal intensive care unit in Thailand.* J Hosp Infect 2019;103(2):151-5. [CrossRef]
6. Khurana S, Kaur H, Biswal M, Saini SS, Ray P, Kumar P. *Association between rectal colonization and risk of blood stream infection with Acinetobacter baumannii in neonates.* Ann Pediatr 2021;4(1):1075.

7. Parm Ü, Metsvaht T, Sepp E, Ilmoja ML, Pisarev H, Pauskar M, et al. Mucosal surveillance cultures in predicting Gram-negative late-onset sepsis in neonatal intensive care units. *J Hosp Infect* 2011;78(4):327-32. [\[CrossRef\]](#)
8. Folgori L, Tersigni C, Hsia Y, Kortsalioudaki C, Heath P, Sharland M, et al. The relationship between Gram-negative colonization and bloodstream infections in neonates: A systematic review and meta-analysis. *Clin Microbiol Infect* 2018;24(3):251-7. [\[CrossRef\]](#)
9. Tacconelli E, Carrara E, Savoldi A, Harbarth S, Mendelson M, Monnet DL, et al. Discovery, research, and development of new antibiotics: The WHO priority list of antibiotic-resistant bacteria and tuberculosis. *Lancet Infect Dis* 2018;18(3):318-27. [\[CrossRef\]](#)
10. Çakmak Çelik F, Aygün C. Bir yenidoğan yoğun bakım ünitesindeki *Acinetobacter baumannii* salgını deneyimi. *Turkish J Pediatr Dis* 2020;14(6):476-9. [\[CrossRef\]](#)
11. Gajic I, Jovicevic M, Milic M, Kekic D, Opavski N, Zrnic Z, et al. Clinical and molecular characteristics of OXA-72-producing *Acinetobacter baumannii* ST636 outbreak at a neonatal intensive care unit in Serbia. *J Hosp Infect* 2021;112:54-60. [\[CrossRef\]](#)
12. Lee HY, Hsu SY, Hsu JF, Chen CL, Wang YH, Chiu CH. Risk factors and molecular epidemiology of *Acinetobacter baumannii* bacteremia in neonates. *J Microbiol Immunol Infect* 2018;51(3):367-76. [\[CrossRef\]](#)
13. Hsu JF, Chu SM, Lien R, Chiu CH, Chiang MC, Fu RH, et al. Case-control analysis of endemic *Acinetobacter baumannii* bacteremia in the neonatal intensive care unit. *Am J Infect Control* 2014;42(1):23-7. [\[CrossRef\]](#)
14. Ponnusamy V, Perperoglou A, Venkatesh V, Curley A, Brown N, Tremlett C, et al. Skin colonisation at the catheter exit site is strongly associated with catheter colonisation and catheter-related sepsis. *Acta Paediatr* 2014;103(12):1233-8. [\[CrossRef\]](#)
15. Mishra A, Mishra S, Jaganath G, Mittal RK, Gupta PK, Patra DP. *Acinetobacter* sepsis in newborns. *Indian Pediatr* 1998;35(1):27-32.
16. Thatrimontrichai A, Tonjit P, Janjindamai W, Dissaneevate S, Maneenil G, Phatigomet M. Risk factors associated with 30-day mortality among neonates with *A. baumannii* sepsis. *Pediatr Infect Dis J* 2021;40(12):1111-4. [\[CrossRef\]](#)
17. Thomas R, Wadula J, Seetharam S, Velaphi S. Prevalence, antimicrobial susceptibility profiles and case fatality rates of *Acinetobacter baumannii* sepsis in a neonatal unit. *J Infect Dev Ctries* 2018;12(4):211-9. [\[CrossRef\]](#)
18. Punpanich W, Nithitamsakun N, Treeratweeraphong V, Suntaratiwong P. Risk factors for carbapenem non-susceptibility and mortality in *Acinetobacter baumannii* bacteremia in children. *Int J Infect Dis* 2012;16(11):e811-5. [\[CrossRef\]](#)
19. Gu Z, Han Y, Meng T, Zhao S, Zhao X, Gao C, et al. Risk Factors and Clinical Outcomes for Patients With *Acinetobacter baumannii* Bacteremia. *Medicine (Baltimore)* 2016;95(9):e2943. [\[CrossRef\]](#)
20. Chen HP, Chen TL, Lai CH, Fung CP, Wong WW, Yu KW, et al. Predictors of mortality in *Acinetobacter baumannii* bacteremia. *J Microbiol Immunol Infect* 2005;38(2):127-36.