

## Reducing central catheter-associated infections in pediatric surgery clinic: Implementation of a care bundle

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### ABSTRACT

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**Purpose:** Central line care bundle comprises a few evidence-based interventions for improving patients' outcomes and recovery process. This semi-experimental study aimed to determine the effect of pediatric central line care bundle implementation on central line-associated bloodstream infections (CLABSI) rates.

**Materials and methods:** A central line care bundle was implemented for pediatric surgery patients (n=70). Baseline observations were made to determine the central line care bundle compliance of healthcare professionals for 435 catheter days. Subsequently, physicians and nurses were educated about the central line care bundle. After the implementation period, 722 catheter days were observed to determine post-implementation compliance. Baseline CLABSI rates were compared with post-implementation CLABSI rates.

**Results:** It was found that the entire central line care bundle compliance was 32.4% pre-implementation

and 86.3% post-implementation. After education, the physicians' and nurses' central line care bundle compliance showed statistically significant improvement (p= 0.0001). There were five CLABSI events in the pre-implementation period and three CLABSI events in the post-implementation period. It was determined that the number of CLABSI decreased in the post-implementation period compared to the pre-implementation period, but this difference was not statistically significant (p= 0.207).

**Conclusions:** Central line care bundle implementation decreased the CLABSI rates. It is recommended the Implementation of a central line care bundle on the care of pediatric surgery patients with the central venous catheter.

**Keywords:** Central venous catheter, care bundle, infection

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## INTRODUCTION

Central line-associated bloodstream infections (CLABSI) are one of the most frequent concerns for patients with central venous catheter. CLABSI causes an increase in morbidity, mortality, length of hospital stay, and hospital expenditures [1-3].

It has been stated that 15 million central venous catheters are applied in intensive care units each year. It is estimated that CLABSI constitutes 80,000 of 250,000 bloodstream infections in intensive care units every year [1,4]. Each year nearly 80,000 CLABSI occur in hospitals; 30,000 of them end up with death. It is also reported that the average cost of CLABSI per patient is about \$ 45,000 and more than \$ 2 billion per year for the US healthcare system [5]. According to the 2013 data of the National Healthcare Safety Network, the ratio of CLABSI varied between 0.0-2.9/1000 catheter days while it was 1.2/1000 in pediatric internal medicine/surgery and 0.3/1000 in pediatric surgery [6]. The Turkish Ministry of Health reported that CLABSI rates in Turkish intensive care units in 2019 varied between 0.0-8.0/1000 catheter days, this rate was 5.6/1000 catheter days in pediatric surgery intensive care unit [7].

Although there are many evidence-based guidelines for the prevention of CLABSI, it is known that there is a gap between the recommendations and the clinical care [1,8,9]. For this reason, the concept of care bundle has been brought up by Institute for Healthcare Improvement (IHI) to achieve the desired outcomes and to increase compliance with the procedures that should always be applied in the same way [4,10,11].

The central line care bundle is one of the first two care bundles developed by IHI [11]. It consists of several interventions that provide a better result when they are applied together compared to when they are applied separately. It usually consists of three to five evidence-based interventions. The follow-up of the bundle is done with the all-or-none principle and it is assumed that there is an incompatibility with all components in case of incompatibility with one of the components. When all items are achieved or a component is substantiated as contraindicated, the bundle is considered to be complete for the patient [10,11]. When the central line care bundle was first developed, it consisted of hand hygiene, maximum barrier measures, skin antiseptics with chlorhexidine, optimal catheter location selection, daily evaluation of the need of catheter, and immediate removal when a central catheter is not required [2,11].

Many studies implemented the central line care bundle to reduce the rate of CLABSI in pediatric patients [5,12,13]. Rinke et al. (2012) conducted a study with pediatric oncology patients and decreased the rate of CLABSI [12]. Duffy et al.

(2015) implemented the care bundle to prevent CLABSI in pediatric oncology patients and reduced the rate of infection [5]. Similarly, Edwards et al. (2015) decreased the CLABSI rates from 5.8/1000 catheter days to 1.4/1000 catheter days in the pediatric intensive care units of many hospitals in the United States by care bundle implementation [13]. Fisher et al. (2013) applied the care bundle during catheterization and care to reduce the rate of CLABSI in 13 newborn units. After the applications, infection rates decreased [14].

In the studies, care bundle applications affected patient and clinical outcomes in a good way. It is suggested that care bundles provide an opportunity for patients to receive care with an evidence-based, standardized approach for the prevention of CLABSI. Therefore, this study was carried out to investigate the effect of the care bundle on CLABSI rates.

## METHODS

This semi-experimental study was carried out to determine the effect of central line care bundle on CLABSI rates in pediatric surgery patients. The data were collected between June 1, 2016, and June 30, 2018, in the Department of Pediatric Surgery of a University Hospital.

The study population consisted of 6481 patients hospitalized in the Department of Pediatric Surgery of the hospital between June 1, 2016, and June 30, 2018. The sample of the study consisted of 70 children aged 0-18 years with central venous catheters, who were hospitalized for the duration of the study, who were allowed to participate in the study by their legal guardians.

### Procedure

In this study, the interventions included in the central line care bundle were determined in line with the principles set by the Institute for Healthcare Improvement and the Joint Commission International (JCI). The Central line care bundle consists of hand hygiene, catheter care, intravenous (IV) sets, and minimizing interventions.

The protocol of this quasi-experimental study consisted of three stages. These are the stages of observation to determine the current situation before the study, training, and the analysis of the effects of post-compliance interventions on CLABSI.

### The stage of observation to determine the current situation before the study

In the first stage of the study, 435 catheter days were observed from June 1, 2016, to May 31, 2017. During this period, the compliance of the hospitalized patients with a central catheter without any training to the central line care bundle was evaluated and recorded daily by observing by the researcher without being noticed.

### Training and Evaluation of the Compliance to the Training

In the second stage of the study, all physicians and nurses working in the pediatric surgery clinic were trained to implement the central line care bundle. In this training program, the description and importance of CLABSI, its importance, the concept of care bundle and its importance in preventing CLABSI, and the interventions in the central line care bundle. Feedback was provided to physicians and nurses on the results of the study before the training. Narrative and question-answer teaching techniques were used. Pieces of training were held during working hours when physicians and nurses were available. The pieces of training were held as group training in the training room in the clinic. Each training took approximately 60 minutes. Physicians and nurses were ensured to participate in the training program in accordance with the study program. This training program was repeated for physicians and nurses who could not attend the training. In the second stage of the study, a total of 33 physicians and nurses received training in four different education programs.

### Analysis of the effects of post-training interventions on CLABSI

In the third stage of the study, the data about the compliance of physicians and nurses to the central line care bundle and CLABSI were compared with the data before the training. Therefore, 722 catheter days were observed between September 1, 2017, and June 30, 2018. The compliance of physicians and nurses to the care bundle was followed up and evaluated daily by the researchers. In all three stages of the study, the condition of full compliance with the four interventions included in the care bundle was sought in the evaluation of the compliance to the central line care bundle. When any of these attempts were made incomplete, it was accepted that the others were also made incomplete. The compliance rate to the central line care bundle was calculated daily. Based on daily compliance, the researchers calculated the mean compliance rates for the pre-and post-training periods. To calculate the compliance rate to the central line care bundle daily, we used the formula specified below and recommended by the IHI was used (Figure 1) [2,11].

$$\text{Central Line Care Bundle Compliance} = \frac{\text{Number of patients with central line who received all four elements of the central line bundle}}{\text{Total number of patients with central line}} \times 100$$

Figure 1. Central Line Bundle Compliance Formula

In this study, the data were obtained from patient files and by observation. Observations were made randomly during the day/night and weekday/weekend is working hours. The physicians and nurses were not informed about the time and place of observations. The researchers observed the interventions approximately 2 hours a day.

To prevent prejudice in terms of the method used, the diagnosis of CLABSI was made independently by the healthcare team. In the clinic, the diagnosis of CLABSI was made by physicians in accordance with the catheter culture results by using the CDC's hospital infection diagnostic criteria. In this study, the status of CLABSI was determined by examining the patient file and obtaining approval from the patient's physician and nurse.

### Data Analysis and Evaluation Techniques

The data obtained from the study were analyzed using Statistical Package for the Social Sciences (SPSS) for Windows 20.0 package program. The personal information about the patients was shown as number, percentage, and mean. The fitness of numerical variables to normal distribution was investigated with the Shapiro-Wilk Test. Crosstabs were used to analyze variables with

nominal and ordinal characteristics and Fisher's Exact Test was performed. For all results,  $p < 0.05$  value was considered statistically significant.

### Ethical Statement

Written permission (Decision Number: 16-3.2/13) was obtained from the Clinical Research Ethics Committee of the Faculty of Medicine of a University for conducting the study. Informed consent was obtained from the legal guardians of the patients for participation in the study. After making the necessary explanations about the objective and application of the study. The relatives of the patients to be included in the study. Written informed consent was obtained for the participation of the patients.

## RESULTS

### Characteristics of the Patients

The distribution of sociodemographic characteristics of the participant patients is shown in Table 1. It was determined that 38.6% (n=27) of the patients were girls while 61.4% (n=43) were boy. 55.7% of the patients (n= 39) between the ages of 0-1 years; 22.9% (n= 16) of them between the ages of 1-3 years; 8.6% (n= 6) of them between the ages of

3-6 years; 5.7% (n= 4) of them were between the ages of 6-12; 7.1% (n=5) of them were between the ages of 12-18. 94.3% (n= 66) of the participated patients survived while 5.7% (n= 4) of them died (Table 1).

47.1% (n=33) of the patients underwent thoracic surgery; 40.0% (n= 28) of them underwent general surgery; 10.0% (n= 7) of them had trauma/burns; 2.9% (n=2) of them underwent urological surgery. Central venous catheter was inserted to subclavian vein (72.9%) (n=51), jugular vein (12.9%) (n=9), femoral vein (12.9%) (n=9), umbilical vein (1.4%) (n=1) of the patients.

The distribution of the patient according to the factors that may affect the development of CLABSI is shown in Table 2. 77.1% (n=54) of the patients had risk factors that may affect the development of CLABSI. 58.6% (n=41) of the patients included in the study were fed parenterally. 34.3% (n=24) of the patients had respiratory failure. In the study, the central venous catheterization procedure was urgently applied to 25.7% (n=18) of the patients. 4.3% (n=3) of them had sepsis; 4.3% (n=3) had burns; 5.7% (n=4) of them had trauma; 2.9% (n=2) of them received immunosuppressant therapy (Table 2).

**Table 1.** Distribution of the patients according to their sociodemographic characteristics

<b>Sociodemographic Characteristics</b>	<b>Number</b>	<b>Percentage</b>
<b>Gender</b>		
Girl	27	38.6
Boy	43	61.4
<b>Age</b>		
0-1	39	55.7
1-3	16	22.9
3-6	6	8.6
6-12	4	5.7
12-18	5	7.1
<b>Mortality Status</b>		
Survived	66	94.3
Died	4	5.7
<b>Total</b>	<b>70</b>	<b>100.0</b>

**Table 2.** Distribution of the patients according to factors able to affect the occurrence of CLABSI

<b>Risk Factors</b>	<b>Number</b>	<b>Percentage</b>
<b>The Status of the Presence of A Risk Factor</b>		
Present	54	77.1
Not present	16	22.9
Parenteral nutrition	41	58.6
Respiratory failure	24	34.3
Emergency catheterization	18	25.7
Trauma	4	5.7
Sepsis	3	4.3
Burns	3	4.3
Immunosuppression	2	2.9

### The Use of Central line care bundle

Table 3 shows the distribution of the compliance status of the physicians and nurses to the interventions in the Central line care bundle according to the study periods. The compliance of the physicians and nurses to hand hygiene was 45.3% (n=197) before the training, while it was 89.6% (n=647) after the training. On the other hand, the compliance level of the physicians and nurses to hand hygiene after the training was statistically

significantly higher compared to that before the training (p=0.0001 p<0.05) (Table 3).

The compliance of the physicians and nurses to catheter care was found to be 46.9% (n=204) before the training and 94.6% (n=683) after the training.

It was determined that the compliance of the physicians and nurses to catheter care statistically significantly increased after the training (p=0.0001 p<0.05) (Table 3).

**Table 3.** Distribution of the status of compliance to the interventions in care bundle according to the periods of the study

Compliance to the Interventions in Care bundle	Pre-training Period		Post-training period		p*
	Number	Percentage	Number	Percentage	
Hand hygiene	197	45.3	647	89.6	0.0001
Catheter Care	204	46.9	683	94.6	0.0001
Replacement of IV sets	237	54.5	710	98.3	0.0001
Minimization of Interventions	381	87.6	721	99.9	0.0001
Full Compliance to Care bundle	141	32.4	623	86.3	0.0001

\* Fisher’s Exact Test

**Findings on the Development of CLABSI**

The comparison of the factors that may affect the development of CLABSI and the status of the occurrence of CLABSI are shown in Table 4.

CLABSI occurred in 18.3% (n=5) of the girls and 7.0% of the boys (n=3). In our study, it was determined that gender did not affect the occurrence of CLABSI (p=0.246).

**Table 4.** Comparison factors able to affect the occurrence of CLABSI and the status of CLABSI

Factors Able to Affect the Occurrence of CLABSI	CLABSI				p*
	Occurred		Not occurred		
	Number	Percentage	Number	Percentage	
Girl	5	18.3	22	81.5	0.246
Boy	3	7.0	40	93.0	
<b>The Status of the Presence of a Risk Factor Risk</b>					0.672
Present	7	13.0	47	87.0	
Not Present	1	6.2	15	93.8	
Immunosuppression	-	-	2	100.0	1.0
Sepsis	1	33.3	2	66.7	0.309
Burns	-	-	3	100.0	1.0
Trauma	-	-	4	100.0	1.0
Emergency catheterization	1	5.6	17	94.4	0.670
Respiratory failure	4	16.7	20	83.3	0.432
Parenteral nutrition	7	17.1	34	82.9	0.128

\* Fisher’s Exact Test

CLABSI occurred in 13.0% (n=7) of the pediatric patients who had a risk factor of the occurrence of CLABSI, and thus, the risk factor did not statistically affect the development of the SAD (p=0.672).

Immunosuppressive therapy (p=1.0), sepsis (p=0.309), burns (p=1.0), and trauma (p=1.0) did not affect the occurrence of CLABSI.

It was determined that CLABSI occurred in 5.6% (n=1) of the patients undergoing emergency catheterization, but emergency catheterization did not affect the occurrence of CLABSI statistically (p=0.670).

16.7% (n=4) of the patients with respiratory failure had CLABSI, and therefore, respiratory

failure did not statistically affect the occurrence of CLABSI (p=0.432).

CLABSI occurred in 17.1% (n=7) of the patients fed parenterally, but parenteral nutrition did not statistically affect the occurrence of CLABSI (p=0.128).

The distribution of the occurrence of CLABSI before and after the training is shown in Table 4. In the study, 5 CLABSI events were diagnosed before the training, and 3 CLABSI events were diagnosed after the training.

The number of CLABSI decreased in the post-training period compared to the pre-training period, but this difference was not statistically significant (p=0.207 p<0.05) (Table 5).

**Table 5.** The distribution of the status of CLABSI before and after the training

Study Periods	Number of CLABSI	p*
Pre-training period	5	0.207
Post-training period	3	

\* Fisher's Exact Test

In our study, it was determined that the 5 cases of CLABSI occurred in the pre-training period; 2 of them were coagulase-negative staphylococci, 1 of them was *Klebsiella pneumoniae*, 1 of them was *Pseudomonas aeruginosa*, and 1 of them was *Candida*. It was determined that the 3 cases of CLABSI occurred in the post-training period were 2 of them were coagulase-negative staphylococcus and 1 of them was *Klebsiella pneumoniae*.

## DISCUSSION

Central catheter-related bloodstream infections are common healthcare-related problems. The care bundles to prevent CLABSI have started to be used frequently. In the literature, the studies indicated that it is possible to decrease or even prevent healthcare-related infection rates by the successful application of care bundles [5,13,15].

Age and gender are among the risk factors in the occurrence of CLABSI. The rates of CLABSI are higher among children, especially in neonates compared to adults. Maleness has been identified as a factor associated with an increased risk of infection [16].

Most patients were hospitalized due to thoracic surgery, followed by general surgery, trauma/burns, and urological surgery patients. Central catheters were inserted into the subclavian veins in ¾ of the patients, they were inserted into the jugular, femoral and umbilical veins of other patients.

Central catheters can be applied to different regions by physicians. The applied area can be important for infection [16]. The guidelines recommend using a subclavian vein instead of using a femoral vein to reduce the risk of infection in adult patients. This risk is believed to be related to the intensity of the skin flora in the central venous catheter insertion site. However, it was stated that femoral catheters have a lower mechanical complication rate in pediatric patients and appear to have an infection rate equal to non-femoral catheters [16].

It was determined that 77.1% (n=54) of the patients had a risk factor that could affect the occurrence of CLABSI. Central venous catheterization was urgently applied to 25.7% (n=18) of the patients.

The Central line care bundle consisted of hand hygiene interventions, catheter care, replacement of IV sets, and minimizing applications.

The American Institute for Health Care Improvement recommended including three to five evidence-based interventions when identifying interventions to be included in the care bundle. It was stated that bringing into compliance is difficult as the number of interventions increases [11]. In the study, the care bundle consisted of four interventions. In the literature, 3-5 interventions were generally applied [5,12,13]. Edwards et al. (2015) conducted studies in many pediatric intensive care units in the United States, it was found that these units used a bundle consisting of the interventions of the selection of the optimal site for catheter insertion, skin disinfection with chlorhexidine, maximum barrier precautions, monitoring of hand hygiene practices, and the evaluation of daily catheter need [13].

Rinke et al. [12] conducted studies with pediatric oncology patients and applied the bundle consisting of the discussion of the necessity of central catheter with a daily medical team, and even aseptic accesses and aseptic procedures during the replacement of the set. Duffy et al. [5] included five interventions in their care bundle studies with pediatric oncology patients [5]. Rinke et al. [17] performed many interventions in care bundles under three main interventions in their studies with oncology patients. In the studies carried out by Fisher et al. [14], eight interventions for catheterization and six interventions for catheter care were used [14]. We determined that the compliance of physicians and nurses to hand hygiene was low before the training. However, their compliance to hand hygiene increased statistically significantly after the training (p=0.0001 p<0.05).

Hand hygiene is an important component of effective patient safety and infection prevention program. Hand hygiene is often considered the most important measure in preventing the spread of infections. It is essential for healthcare professionals to be informed about the practices recommended for hand hygiene and to comply with them continuously. Health institutions should include hand hygiene in routine procedures and have strong systems to support, monitor, and encourage correct hand hygiene behaviors [16]. Health institutions should ensure that healthcare professionals are trained in effective hand hygiene, and handwashing facilities are available. Thus, healthcare staff can disinfect their hands immediately before and after each part of direct contact or care [9].

In the studies on the central line care bundle, hand hygiene was found to be a common intervention [5,13,14].

It was determined that the compliance of physicians and nurses to catheter care statistically significantly increased after the training ( $p=0.0001$   $p<0.05$ ). Catheter care may be required more frequently for some reasons (secretion, sweating, etc.) and therefore the risk of infection may increase.

It was determined that the compliance of the physicians and nurses to the replacement of IV sets statistically significantly increased after the training ( $p=0.0001$   $p<0.05$ ). The compliance of the physicians and nurses to the minimization of the interventions made via the central catheter statistically significantly increased after the training ( $p=0.0001$   $p<0.05$ ). The best compliance was obtained in the intervention to minimize the interventions applied through the central catheter from the interventions in the care bundle.

In this study, the compliance to the Central line care bundle was found to be statistically significantly higher after the training ( $p=0.0001$   $p<0.05$ ). In the study of Rinke et al. [17], the compliance to the bundle was checked by the clinical nurse with an average of 3 bundles in the last 3 months of the intervention period. Accordingly, the compliance levels to aseptic insertion, aseptic replacement of central catheter dressing, family assessment were found to be 100%, 85%, and 81%, respectively.

In the study, 5 CLABSI events were detected before the training, and 3 CLABSI events were detected after the training. It was determined that the number of CLABSI attacks decreased in the post-training period compared to the pre-training period, but this difference was not statistically significant ( $p=0.207$ ).

In the literature, it was observed that the infection rates decreased [5,13,15]. Rinke et al. (2012) conducted a study with pediatric oncology patients, the rates of CRBSI decreased from 2.25/1000 per 1000 central catheter days to 1.79/1000 per 1000 central catheter days during the intervention period [12]. Rinke et al. conducted another study with outpatient oncology patients, a 48% decrease was observed in infection rates; it decreased from 0.63/1000 per 1000 central catheter days to 0.32/1000 after the application, and the difference was statistically significant ( $p=0.005$ ) [17]. Duffy et al. (2015) showed a decrease in infection rates in their study with oncology patients [5]

Edwards et al. [13] conducted a study in pediatric intensive care units of several hospitals; they found that the rate of infection decreased from 5.8 per 1,000 catheter days to 1.4 from 2006 to 2011-2012 ( $p<0.001$ ). The infection rate was lower in intensive care units with a compliance rate of 95% to infection prevention bundles, but this relationship

was not statistically significant [13]. Fisher et al. [14] conducted a study in 13 newborn units by implementing a care bundle for reducing the rate of CLABSI, the infection rate was reduced from 3.94 to 1.162 per 1000 catheter days throughout the year ( $p=0.01$ ). In a similar study conducted by Ormsby et al. (2018), the rate of compliance to the care bundle came up 90%, and the rate of CLABSI decreased from 1.41/1000 catheter days to 0.40/1000 catheter days [15]. Devrim et al. (2018) implemented the central line bundle for pediatric oncology patients with portable devices which decreased the CLABSI from 14.5/1000 catheter days to 2.63/1000 catheter days [18]. Bannatyne et al. [19] carried out a study with newborn infants that decreased the CLABSI rates from 8.8/1000 catheter days to 4.9/1000 catheter days after implementing the central line bundle [19]. Similarly, Kulali et al. [20] reported that the Implementation of a central line bundle decreased umbilical catheter-related bloodstream infection rates from 12.4/1000 catheter days to 3.9/1000 catheter days in a neonatal intensive care unit.

In our study, 5 CLABSI cases occurred before the training; 2 of them were due to coagulase-negative staphylococci, one of which was due to *Klebsiella pneumoniae*, one of which was due to *Pseudomonas aeruginosa*, and one of them was due to *Candida*. 3 CLABSI cases occurred after the training, two of them were due to coagulase-negative staphylococci, and one of them was due to *Klebsiella pneumoniae*. Rinke et al. [12] determined that 50% of infections are caused by Gram-positive pathogens. In their study with outpatient oncology patients, Rinke et al. [17] showed that there were growing microorganisms in 81 patients before administering the bundle, and this number decreased to 33 after the application. While coagulase-negative staphylococci ( $n=18$ ) were the most common among gram-positive organisms, *Enterobacter spp* ( $n=10$ ) was the most common among gram-negative microorganisms. *Candida albicans* were also observed in 2 cases. After the application, coagulase-negative staphylococci ( $n=12$ ) were the most common among gram-positive organisms, while *Klebsiella spp.* ( $n=3$ ) was the most common among gram-negative organisms. *Candida albicans* were not observed after application [17].

Prevention of CLABSI is fundamental for improving care quality and patient safety. Implementation of the central line bundle is an effective and simple way of putting evidence-based recommendations into clinical practice. Therefore, this method can enhance reducing CLABSI rates among pediatric surgical patients.

The third stage of our study's central line care bundle compliance rates may not have fully reflected the real compliance outcomes. Because of becoming awake to observations made by researchers, the

compliance rates of physicians and nurses may have increased over time.

## CONCLUSIONS

In this study, it was determined that it is possible to decrease the number of CLABSI by implementing the Central line care bundle. This decrease in CLABSI rates was suggested to affect the training of physicians and nurses and the Implementation of the Central line care bundle. It has been recommended to use the Central line care bundle in the care of pediatric patients with central venous catheters. It has also been suggested to support the Central line care bundle by conducting the studies with more patients throughout the hospital, by establishing teams consisting of physicians, medical students/nurses, and assistant personnel who contact patients and may cause the colonization of microorganisms in them. To ensure compliance to the Central line care bundle at high rates, periodic repetition, rewarding, and administrative sanctions have also been recommended.

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## Conflicts of interest

No conflict of interest was declared by the authors.

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