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Effect of Personalized Music Intervention in Mechanically Ventilated Children in Pediatric ICU: A Pilot Study

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Article Tweet: personalized music comforts mechanically ventilated children in PICU. #PedsICU @JosLatour1

Contribution of Authors:

MhL, LhZ, JxP, XpZ, ZhX, QjL, JQ, JML Contributed to the development of the research protocol. LZ secured funding support of the project; JxP and QjL ensured nursing support in delivering the intervention and data collection; JQ contributed to data analysis; MhL, LhZ, ZhX, JML contributed to data collection and data interpretation; MhL and JML wrote the first draft of the manuscript; all authors contributed to the final manuscript.

ABSTRACT

Objective: To determine the feasibility of a personalized music intervention with mechanically ventilated patients in the Pediatric Intensive Care Unit.

Design: Pilot study with a quasi-experimental design.

Setting: Tertiary children's hospital in China with a 40-bed Pediatric Intensive Care Unit.

Patients: Children, 1 month to 7 years, with mechanical ventilation were recruited and assigned to music group (n=25) and control group (n=25).

Intervention: Children in the music group received their own favorite music and listened for 60 minutes three times a day. The control group receive routine care without music.

Measurements and Main Results: Primary outcome measure was comfort measured with the COMFORT-B scale five minutes before and after the music. Secondary outcome measures were physiological parameters; heart rate, respiration, blood pressure, oxygen saturation. Mechanical ventilation time, length-of-stay, and sedation medication were also collected. Qualitative analysis revealed that nurses had a positive attitude in delivering the interventions and identified improvements for the main trial. Children in the music group had lower COMFORT-B scores (15.7 versus 17.6; $p=0.011$). Children in the music group had better physiological outcomes; heart rate (140 vs 144; $p=0.039$), respiration rate (40 vs 43; $p = 0.036$), systolic blood pressure (93mmHg vs 95mmHg; $p=0.031$), oxygen saturation (96% vs 95%; $p<0.001$), diastolic blood pressure was not significantly (52mmHg vs 53mmHg; $p=0.11$). Children in the music group had a shorter ventilation time (148.7 vs 187.6; $p=0.044$) and a shorter length-of-stay, but not significant (11.2 vs 13.8; $p=0.071$). Children in the control group had higher total amount of on-demand midazolam (29mg vs 33mg; $p=0.040$).

Conclusion: Our pilot study indicates that personalized music intervention is feasible

and might improve the comfort of children with mechanical ventilation. Further studies are needed to provide conclusive evidence in confirming the effectiveness of music interventions comforting critically ill children in Pediatric Intensive Care Units.

Keywords: Music Intervention; Pediatric Intensive Care Units; Mechanical Ventilation; Patient Comfort; Children;

INTRODUCTION

Children admitted to Pediatric Intensive Care Units (PICUs) because of acute critical illness can develop feeling of fear and stress due to the unfamiliar environment or alarming sounds of monitors (1). Intensive care treatment and procedures can increase pain, discomfort and stress experiences in mechanically ventilated patients (2, 3). From a physiological point, stress may lead to changes in autonomic activity manifested with increased heart rate and blood glucose (4), which may increase mechanically ventilated time in children. Therefore, implementing interventions to reduce stress and provide comfort to critically ill children are important to consider by PICU healthcare professionals.

In recent years, more attention is given to non-pharmacological interventions such as music therapy, touch, or massage to relieve stress of hospitalized patients and children (5-10). Studies looking at the effect of music interventions are mostly performed in adult intensive care units (9, 11-12) or in premature infants in Neonatal Intensive Care Units (13). The effect of music in children is scarcely investigated (14). However, other healthcare settings have been using music interventions for a prolonged time. A review and meta-analysis of randomized controlled trials (RCTs) testing music interventions on pain included 97 articles published between 1995-2014 (15). The primary outcome of pain intensity improved significantly and secondary outcome measures such as emotional distress, use of sedatives, heart rate, blood pressure, and respiration rate showed beneficial results. In the subgroup-analysis with eight RCTs with children as study participants, the meta-analysis of pediatric studies had better outcomes than the adult studies. However, the authors mentioned that this should be interpreted with caution because of the heterogeneous outcomes of the included studies (15). Unfortunately, none of the included RCTs were performed in PICUs. This gap in the current evidence would need to be addressed and studied given the promising effects in other pediatric specialties.

Review reports have demonstrated a positive effect of music interventions in

pediatrics and in adults (12, 16). However, the choice of music provided to patients is crucial to achieve the beneficial effect. A study testing happy and sad music with patients documented that pleasant music is more effective on patients' pain relief (17). The authors of this study conclude that healthcare professionals should use music from the patient's preference (17). Therefore, personalized music would possibly be preferred in critically ill children providing personalized patient care.

Whether music interventions can improve the comfort of critically ill children in the PICU is to our knowledge sparsely studied. A pilot study in Canada tested the feasibility of a comfort intervention including touch, reading, and music among 20 children in the PICU (18). Age-appropriate music was provided up to 1 hour that was developed by a music therapist in agreement with the parents. The feasibility measures were promising towards the acceptability of the intervention. The COMFORT scale was used during PICU stay to measure child's distress with the scale dimensions behavioral and physiologic while post-PICU distress and anxiety was measured using the Revised Children's Manifest Anxiety Scale and the Children's Critical Illness Impact Scale. The small study sample suggests an initial positive effect of the psychological well-being of children and parents and supports a large-scale trial (18).

Further clinical studies are needed to confirm the clinical effectiveness of music interventions with mechanically ventilated children in PICU. In order to perform a full RCT, we conducted a pilot study to determine the feasibility of a personalized music intervention on comfort and sedation in mechanically ventilated patients in the PICU.

MATERIALS AND METHODS

Design

In line with the Medical Research Council guidance on developing and evaluating complex interventions, we planned a pilot study using a quasi-experimental design with an intervention and control group due to the limitations of blinding in delivering the

intervention and data collection (19-21). The study was conducted between December 2016 and October 2017. The Checklist for Reporting Music-based Interventions was used as the standard for reporting our study (22).

Setting

The study was conducted in Hunan Children's hospital, Changsha, China. The 40-bed PICU serves as regional tertiary center admitting critically ill children from 28 days to 16 years of age. Like many PICU settings in China, parents have restricted access to visit their child in the PICU. Parents of critical ill children can visit their child. If the child is stable, the policy is that parents cannot visit the child at the bedside. However, parents have a meeting with the medical team three times a week.

Participants

Because the nature of the pilot study, no power analyses was performed to determine the sample size. The sample size was therefore set at 50 patients (25 in the intervention group and 25 in the control group).

Inclusion criteria were children aged between 1 month and 7 years of age with no hearing difficulties and with expected mechanical ventilatory support for at least 48 hours after inclusion. The age range was set to 7 years as these are the majority of children admitted to our PICU. Hearing difficulties were assessed by asking the mother for any hearing problems. Children were excluded if they had a neurocognitive disorder, with a post-operative admission, or a critical situation where end-of-life care was expected.

Recruitment and Randomization

A research nurses recruited the children. On the odd days, eligible children were recruited and allocated to the intervention group and on the even days eligible children were recruited and allocated to the control group. Children were included after the parents signed the written consent form. The intervention group received standard care

and personalized music; the control group received standard care only.

Personalized Music Intervention and Standard Care

Mechanically ventilated children in the intervention group received personalized music from the time of mechanical ventilation and study inclusion until the day the child was extubated. Parents were asked to provide the child's favorite music. Of the included children, 22 parents provided the child's favorite music tracks on a MP3 player. In three cases the parents did not have or did not know the child's preferred music. In these cases, the children received soothing baby music for infants or children's songs for preschool stage children. The music was provided by a music player (Phillips, SBM100/93) and headphones (Philips, SHM7110) which were placed at 5cm at the horizontal distance of the child's ear (Electronic Supplement Material 1). The music was provided for 60 minutes at times when normally less clinical interventions were scheduled; in the morning (07:00-08:00hrs), at noon (11:30-12:30hrs), and evening (21:00-22:00hrs). The sound was controlled at 30-50dB, and the music had around 60-80 beats per minute. Standard care was provided in the control group and did not involve any music. Blinding between both groups was not possible for staff because those children with the music intervention were visible to all staff given the open plan environment and design of the PICU.

Outcomes and Measurements

Primary outcome measure was comfort measured with the Chinese version of the COMFORT Behavior (COMFORT-B) scale (23, 24). The COMFORT-B scale is currently one of the tools widely used to assess sedation levels in critically ill children. The scale consists of six behavioral indicators; alertness, calmness, respiratory response or crying, physical movement, muscle tone, and facial tension. Each item is assessed based on a 5-point Likert scale, from 1 (no distress) to 5 (severe distress). The total score ranged from 6 to 30 points, and each patient needs to be observed for two minutes. The cutoff points of the COMFORT-B scale are 10 and 23 where ≤ 10

represents no undersedation and ≥ 23 represents under sedated. Thus, the higher the score, the lower the comfort (24).

The secondary outcomes were changes in heart rate, respiration rate, blood pressure, oxygen saturation, length of mechanical ventilation time (in hours), length-of-stay PICU (in days), standard prescribed use of midazolam provided by continuous drip (in mg), and on-demand dosing of midazolam (in mg).

Children in the intervention group were observed and data were collected at two time points during the music intervention: T1 is 5 minutes before the start of the music and T2 is 5 minutes after the music stopped. The measures were repeated at every music session three times a day. Data of children in the control group were collected three times a day at the same two time points as the children in the intervention group. For example, in the morning the data was collected T1 at 06:55 and T2 at 08:05hrs.

Blinding of the outcome measures was not possible. The nurses measuring the COMFORT-B scale could see which child received the music intervention because of the use of the headphones in the intervention group. The secondary outcome measures could not be influenced by the observers because this data is collected by bed-side computers. All collected data were anonymized before analysis.

The feasibility of the music intervention was explored by providing six nurses an open-ended questionnaire to write their experiences of delivering the intervention. The main questions were related to: problems experienced while delivering the interventions; suggestions to improve the interventions; measurements of outcome measures; role of parents; general experiences.

Data analysis

The distribution of study participants' characteristics was summarized by descriptive statistics. Further descriptive statistical analysis of the outcome measures used means and standard deviation. Measurements of the two timepoints before and after the intervention were summed and average scores of each child were calculated.

Differences between groups were tested using the Student t-test for continuous variables and Chi-square test for categorical variables. The Kolmogorov-Smirnov test (used when $n < 50$) was used to determine if the data was normally distributed. In case the data was non-normally distributed, the Mann-Whitney U test was used. IBM SPSS Statistics for Windows, Version 21.0 (Armonk, NY: IBM Corp.) was used. Differences were statistically significant with a p -value < 0.05 . The free text of the open questionnaire of nurses with feasibility questions were analyzed using content analysis.

Ethical considerations

Ethical approval was provided by the Research Ethics Committee of Hunan Children's Hospital (approval number: HCHLL-2016-019). The aim of the study was communicated to parents verbally and by a patient information sheet. Parents were able to withdraw their child from the study at any time. Signed written informed consent was requested and collected before including the children into the study.

RESULTS

In total, 53 mechanically ventilated children were eligible for study inclusion. Of these, three children were excluded because parents decided to withdraw treatment due to expected poor outcome and financial implications (**Fig. 1**). There were 25 children in the intervention group of which 16 males and 9 females with a median age of 7 months. Other characteristics are further presented in **Table 1**. The control group included 25 children; 12 males and 13 females with a median age of 5 months. Both groups did not differ significantly in terms of age, weight, gender, intubation, diagnosis, basic mechanical ventilation settings and the Pediatric Critical Illness Score (25) widely used in China instead of pediatric risk scores.

The feasibility of the intervention was generally experienced as a positive intervention by the nurses. Like one nurse wrote: "Music therapy can shift the attention and relieve discomfort of the child during mechanical ventilation, thereby reducing their

anxiety.” There were not many problems reported while delivering the intervention. However, nurses reported suggestions that are valuable for the main study such as having the flexibility of the duration of the intervention, specifically when emergency procedures are needed. Also, one nurse reported that the timepoints of measuring the COMFORT-B scale was difficult to maintain and suggested more timepoints. Others suggested to have the outcomes measured every 15 minutes while delivering the music intervention. Improvements of the music intervention was provided and included the use of Bluetooth earphones but not placing these in the ear, change the timings of the interventions to align better with the ‘rest-hour’ of the PICU, and a suggestion was made to consider doing a study on the length of the music intervention (30 min versus 60 min). Finally, most nurses were afraid that parents would increase the anxiety of children. This view of some nurses might be because of the limited experiences having parents at the child’s bedside without restrictions. However, one nurse questioned the impact of parents as a confounding factor when running this study by writing: “If the parents are near, we don’t know which contribute to the stable vital signs of the child, and children would pay more attention to parents not to music.”

The primary outcome was comfort measured with the COMFORT-B scale. In our study, nurses were trained to use the COMFORT-B scale including the observations and use of the scale. The interrater reliability resulted in a Kappa of 0.78 which was lower, but still sufficient, as reported in a review with Kappa’s ranging between 0.82 to 0.98 (26). Before the intervention, there was no significant difference in comfort scores between both groups. After the intervention, the comfort score of the intervention group was lower than the control group ($p=0.011$) indicating the intervention group had more comfort than the control group (**Table 2**). After the music intervention, the intervention group had lower comfort scores than at the start of the intervention ($p=0.001$). In the control group there were no differences observed between the two time points (**Table 2**).

Secondary outcomes of vital signs were collected. All vital signs measured at time

point 1 (5 minutes before the music intervention and similar time for the control group) did not show significant differences between both groups; heart rate ($p=0.722$); respiration rate ($p=0.653$), systolic blood pressure ($p=0.093$), diastolic blood pressure ($p=0.324$); oxygen saturation ($p=0.257$). At time point 2 (5 minutes after the music intervention and similar time for the control group), the vital signs heart rate, respiration rate, systolic blood pressure and oxygenation improved significantly in the intervention group (**Table 3**). The only vital sign that did not differ was diastolic blood pressure.

In the intervention group, all vital signs improved significantly between time point 1 and 2 (**Table 4**). Furthermore, the clinical outcomes between both groups showed significant differences in mechanical ventilation time ($p=0.044$). The use of midazolam only showed difference between groups receiving the on-demand midazolam ($p=0.040$) while the total amount of midazolam (standard prescribed and on-demand) did not differ. No difference was observed in the PICU length-of-stay (**Table 5**).

DISCUSSION

The aim of our pilot study was to evaluate the feasibility of a non-pharmacological intervention in mechanically ventilated children in the PICU. The results of our pilot study showed that personalized music supported sedation levels and improved most clinical outcomes. Studies have shown that music interventions can be effective complementary methods for reducing acute and chronic pain (12, 16). Our study applied a music intervention for 60 minutes three times a day with personalized music. Creating a homely atmosphere that is recognizable for children might relieve physical and psychological stress. Our findings demonstrated statistical difference between a COMFORT B scores and respiratory outcome measures. Although the difference was significant, these were small, and it can be argued if these were clinically meaningful. Other outcome measures might need to be considered to enhance the clinical importance and impact on clinical and long-term outcomes when implementing and

testing music interventions.

Although our study included a small sample, the findings indicated that music can be beneficial to the child's clinical outcomes and can provide PICU colleagues with a simple and cost-effective non-pharmacological intervention.

Our study has similar results with studies conducted in China. Wei and colleagues demonstrated that music among 30 premature infants improved the vital signs of infants such as heart rate, respiration and oxygenation levels (27). Similar as in our study, mothers chose the type of music that they thought was important for their infants. Another study in China looked at the use of music in children with severe encephalitis (28), demonstrating that the music intervention group had significant better clinical outcomes compared to the control group ($p < 0.05$). This study included 66 children divided in a music group and a control group. Although these studies have shown similar promising outcomes, the studies are small in terms of study population making it difficult to generalize the benefit of music interventions in children. The review and meta-analysis of Lee identified only five RCTs of music interventions with children ($n=344$) as study participants (15). Therefore, larger RCTs are needed to establish sound evidence of the use of music interventions, specifically in PICU.

Mechanically ventilated patients in the intensive care are often prone to a stressful environment and most patients require sedative analgesia to minimize anxiety and discomfort. Sedative can be insufficient or excessive and might cause negative patient clinical outcomes (29, 30). Insufficient sedation can lead to increased pain, anxiety, and disturbed factual and delusional memories (1, 31). The same has been demonstrated for excessive sedation as well; excess sedation can lead to poorly controlled pain, delirium, and distorted memory that can contribute to post traumatic stress disorders, anxiety, and depression in intensive care survivors (32-34). A study demonstrated that children undergoing electroencephalography testing with sedation medication and music needed significantly lower sedatives than the control group without music (35). Under certain conditions, music might become a complementary

alternative for sedation medication. However, in our study on-demand midazolam was provided to the children even though the total use of midazolam did not provide significant differences between both groups.

Studies reporting music interventions can be challenging to compare results due to the complexity and differences of music interventions. Although guidelines of reporting music-based interventions are available (22), describing a music intervention can be difficult. This can be related to the complexity of the intervention such as music rhythm, tempo, harmonic structure, and variety of active or receptive music listening. A systematic review of 187 articles concluded that reporting of music intervention studies was poor making it problematic for cross-study data interpretation and comparison (36). The authors used the checklist for reporting music interventions (22) and documented an overall reporting quality of less than 50% based on four of the seven components in the checklist. This included also information about the delivery of a music intervention (36). Although our pilot study was designed to test a personalized music intervention and we reported in detail the intervention, the variety of music and use of headphones might influence the standardized delivery of the intervention due to age range of children in the PICU.

Several study limitations need to be addressed. A limitation is that we did not explore the attitude of PICU staff in delivering the music in our pilot study. Although a small team of six colleagues delivered the intervention, it could be possible that medical and nursing staff might have different views towards implementing a music intervention. This is an important factor for a successful delivery of the main RCT. A methodological limitation is the fact that blinding was not possible which could have influenced the outcome measures. Also, age limit of the study participants (up to 7 years of age) might not represent the full PICU population. Finally, it can be argued that the fixed timing of providing music is not patient-centered friendly.

This pilot study provided valuable information for the future main trial. First, the hardware, using headphones, could be improved given the availability of new devices

such as SleepPhones headbands described in the feasibility study by Rennick and colleagues (18). Second, we will aim to include all children regarding the age group. Third, the length of music intervention should be flexible and depend on the child's needs. Third, like most PICUs in China, parents have restricted visiting access. The role of parents should not be underestimated and allowing parents to be with their child is important to provide a more individualized music interventions where parents have the best knowledge of their child's behavior. Finally, blinding needs careful consideration. Particularly blinding in data collection is important to ensure robust and trustworthy results of the main RCT. An alternative is to extend the study with other PICUs and use a stepped-wedge cluster randomized trial design to overcome the blinding of the intervention (37). We also suggest including long-term outcomes. However, collecting long-term follow-up data would need careful consideration given the geographic distance and the relatively low attendance of follow-up clinics by children and parents in our hospital.

CONCLUSION

This pilot study demonstrated that personalized music is feasible and might be beneficial in mechanically ventilated children in the PICU. The result indicated that personalized music supports sedation levels. The vital signs heart rate, respiration rate, systolic blood pressure and oxygenation improved after the music intervention. The length of mechanical ventilation time was decreased and children with the personalized music intervention needed less additional sedatives. Further trials are needed to confirm music interventions can be an effective non-pharmacological intervention and providing conclusive evidence to enhance comfort in critically ill children.

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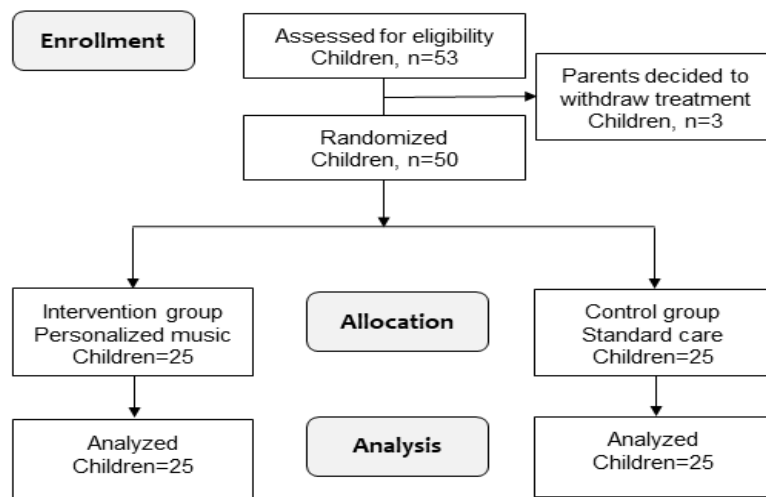


Fig 1. Study flow diagram

Table 1. Characteristics of Children

Children	Intervention group (n=25)	Control group (n=25)	<i>p</i>
Age in months (median, P25-P75)	7 (5,16.5)	5 (1.5,18.5)	0.800
Weight in kg (mean; SD)	7.64 (3.45)	7.26 (3.83)	0.714
Gender (n, %)			
Male	16 (64)	12 (48)	0.254
Female	9 (36)	13 (52)	
Intubation (n, %)			
Nasal intubation	18 (72)	20 (80)	0.508
Oral intubation	7 (28)	5 (20)	
Ventilatory Parameters			
FiO2 in % (median, P25-P75)	40 (40; 40)	40 (40; 40)	0.716
PEEP in cmH2O (median, P25-P75)	5 (5; 5)	5 (5; 5)	0.828
Diagnosis (n, %)			
Severe pneumonia	15 (60)	16 (64)	0.771
Severe encephalitis	5 (20)	6 (24)	
Sever sepsis	2 (8)	2 (8)	
Others	3 (12)	1 (4)	
PCIS (median, P25-P75)	78 (78,80)	77 (77; 80)	0.734

SD=Standard Deviation. Other diseases: In intervention group, 1 case of leukemia, 1 case of upper airway obstruction, and 1 case of biliary atresia; in control group ,1 case of metabolic encephalopathy.

Table 2. Comparison of COMFORT-B scores between groups and between two time points

Group	n	T1 mean (SD)	T2 mean (SD)	t	p
Intervention group	25	17.8 (1.57)	15.7 (3.33)	4.12	<0.001
Control group	25	18.1 (0.82)	17.6 (1.38)	1.52	0.142
t		0.89	2.64		
p		0.376	0.011		

SD=Standard Deviation. T1 for the intervention group was 5 minutes before the music therapy; T1 for the control group was 5 minutes at the same time point of intervention group. T2 for the intervention group was 5 minutes after the music therapy; T2 for the control group was 5 minutes at the same time point of intervention group.

Table 3. Comparison of vital signs between both groups at time point 2 (5 minutes after the end)

Vital signs	Intervention group n=25 mean (SD)	Control group n=25 mean (SD)	t	p
HR (beats/min)	139.6 (7.58)	144.3 (8.24)	2.12	0.039
Respiration (rate/min)	40.2 (6.20)	43.3 (3.65)	2.16	0.036
Systolic blood pressure (mmHg)	92.6 (3.36)	94.8 (3.64)	2.23	0.031
Diastolic blood pressure (mmHg)	51.8 (2.91)	53.1 (3.12)	1.59	0.118
SpO ₂ (%)	95.8 (1.13)	94.5 (0.47)	-5.32	<0.001

SD=Standard Deviation. HR=Heart Rate; SpO₂=Oxygen saturation

Table 4. Comparison of vital signs of intervention group at time point 1 and 2

Intervention group n=25	T1 mean (SD)	T2 mean (SD)	t	p
HR (beats/min)	145.4 (9.21)	139.6 (7.58)	9.61	<0.001
Respiration (rate/min)	42.7 (3.70)	40.2 (6.20)	2.21	0.037
Systolic blood pressure (mmHg)	95.0 (5.35)	92.6 (3.36)	3.50	0.002
Diastolic blood pressure (mmHg)	55.6 (5.14)	51.8 (2.91)	5.86	<0.001
SpO ₂ (%)	94.2 (0.79)	95.8 (1.13)	-7.59	<0.001

SD=Standard Deviation. HR=Heart Rate; SpO₂=Oxygen saturation; T1 was 5 minutes before the music therapy; T2 was 5 minutes after the music therapy.

Table 5. Comparison of mechanical ventilation time, length-of-stay PICU, and midazolam

Clinical outcomes	Intervention group n=25	Control group n=25	t / Z	p
MV time in hours (mean, SD)	148.7 (60.05)	187.6 (72.22)	2.07	0.044 [#]
Length-of-Stay: PICU in days (mean, SD)	11.2 (3.45)	13.8 (6.14)	1.85	0.071 [#]
Standard prescribed midazolam in mg (median, P ₂₅ -P ₇₅)	77.3 (39.95; 116.55)	82.1 (34.85; 143.77)	-0.349	0.727 [*]
On-demand midazolam in mg (median, P ₂₅ -P ₇₅)	29 (20; 35.5)	33 (28; 37)	2.11	0.040 [*]
Standard prescribed + On-demand midazolam in mg (median, P ₂₅ -P ₇₅)	111 (73.28; 156.05)	112 (62.89; 166.55)	-0.010	0.992 [*]

MV=Mechanical Ventilation; PICU=Pediatric Intensive Care Unit; mg=milligram; SD=Standard Deviation; [#] Student t test; ^{*} Mann-Whitney U test.

Electronic Supplement Material 1

