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Delivery Room Management of Infants with Very Low Birth Weight in 3 European Countries—The Video Apgar Study

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Objective To assess delivery room management of infants born preterm at 4 Level III perinatal centers in 3 European countries.

Study design This was a prospective, multicenter observational study. Management at birth was video-recorded and evaluated (Interact version 9.6.1; Mangold-International, Arnstorf, Germany). Data were analyzed and compared within and between centers.

Results The infants (n = 138) differed significantly with respect to the median (25%, 75%) birth weight (grams) (Center A: 1200 [700, 1550]; Center B: 990 [719, 1240]; Center C: 1174 [835, 1435]; Center D: 1323 [971, 1515] [B vs A, C, D: $P < .05$]), gestational week (Center A: 28.4 [26.3, 30.0]; Center B: 27.9 [26.7, 29.6]; Center C: 29.3 [26.4, 31.0]; Center D: 30.3 [28.0, 31.9]), Apgar scores, rates of cesarean delivery, and time spent in the delivery room. Management differed significantly for frequency and drying time, rates of electrocardiographic monitoring, suctioning or stimulation, and for fundamental interventions such as time for achieving a reliable peripheral oxygen saturation signal (seconds) (Center A: 97.6 ± 79.3; Center B: 65.1 ± 116.2; Center C: 97.1 ± 67.0; Center D: 114.4 ± 140.5; B vs A, C, D: $P < .001$) and time for intubation (seconds) (Center A: 48.7 ± 4.2; Center B: 49.0 ± 30.7; Center C: 69.1 ±37.9; Center D: 65.1 ± 23.8; B vs D, $P < .025$). Mean procedural times did not meet guideline recommendations. The sequence of interventions was similar at all centers.

Conclusions The Video Apgar Study showed great variability in and between 4 neonatal centers in Europe. The study also showed it is difficult to adhere to published guidelines for recommended times for important, basic measures such as peripheral oxygen saturation measurements and intubation. *(J Pediatr 2020;222:106-11)*.

Support of infants born preterm immediately after birth poses a significant challenge but a standardized approach to care, especially in infants born preterm, may have a positive influence on morbidity and mortality.[1] Such standards are regularly published by the European Resuscitation Council[2] as well as by the American Heart Association (Neonatal Resuscitation Program).[3,4] These standards have been subject to significant changes during the last decade. Goals for timing have been established for steps such as obtaining an adequate pulse oximeter reading[2-4] or intubation.[4] Apart from these international guidelines, there are also local and national standard procedures,[5,6] with differing approaches to caring for infants who are newly born.[7,8] However, data that describe the variance between hospitals and individual approaches are rare and not based on objective data collection.

Videography combined with standardized structured analysis is a valuable tool for comparing and evaluating delivery room management[9-13] and may provide information about teamwork and potential areas for improvement by means of targeted training. Thus, video recording has gained importance in recent years, particularly in neonatology.[9] The aim of this study is to assess, prospectively describe, and compare delivery room management during postnatal transition of infants with very low birth weight in 3 European countries.

Methods

The Video Apgar Study was a prospective, multicenter observational study of infants born very preterm born between January 2009 and December 2014 at 4 intensive care units in Austria, Germany, and the Netherlands. Infants with a gestational age of ≤32 weeks or a birth weight ≤1500 g were eligible for enrollment. Infants who did not receive life support (ie, due to severe congenital malformations) were not included. Informed consent was obtained from parents preferably

NICU	Neonatal intensive care unit
SpO_2	Peripheral oxygen saturation

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before delivery; alternatively, deferred consent was obtained (Centers B and C), eg, in cases of emergency delivery. Consent was obtained from the nursing staff and physicians. The study was approved (Ethics Committee Göttingen, Vorarlberg, Dresden) or a declaration of no objection was obtained (Medisch-Ethische Toetsingscommissie, METC Leiden).

All infants were managed on a resuscitation table (Dräger, Lübeck, Germany) or in an incubator (Giraffe Incubator Carestation; General Electric, Boston, Massachusetts) using an overhead radiant warmer. All infants were treated by neonatologists as the responsible leader of the team with fellows or residents and a nurse. Treatment adhered to the European Resuscitation Council's guidelines.[2] In center B, the delivery room was next to the neonatal intensive care unit (NICU), whereas the other centers had more distant NICUs.

Videos were recorded using a predefined setting: a commercially available web camera (eg, QuickCam S7500; Logitech, Lausanne, Switzerland) connected to the overhead warmer. The camera showed only the infant, the hands of the medical staff, and the pulse oximeter (Massimo Corporation, Irvine, California). Recording was performed from the time of birth until the infant left the resuscitation table to be transported to the NICU. All video recordings from all study centers were analyzed by a single person not involved in the care of these patients and validated by a second assessor. Data were anonymized.

Interventions were prospectively defined as follows: initial drying, time for suction, obtaining venous access, time to achieving a sufficient pulse oximeter signal (peripheral oxygen saturation [SpO_2]), or time for intubation (defined as time between laryngoscope entering and exiting the mouth). Periods of rest were defined as time interval without any manipulations. Time goals were specified for achieving a sufficient SpO_2 signal[2,3] by 60 seconds and for intubation[4] by 30 seconds.

Video recordings were evaluated using Interact version 9.6.1 (Mangold-International, Arnstorf, Germany). This software allows depiction of results for point of time, quantity, and duration of interventions.

Statistical Analyses

All parameters were first tested for normality of variable distribution using the Kolmogorov–Smirnov test. Differences in intervention characteristics for the 4 centers were tested with the Kruskal–Wallis test (not shown). Differences in interventions between the individual centers were determined post-hoc using the Mann–Whitney *U* test. Results were described as mean and SD, as well as median and IQR. Calculations were performed with Microsoft Excel 2007 (Microsoft, Redmond, Washington) and SPSS Statistics 25 (IBM Corp, Armonk, New York). A *P* value <.05 was considered significant.

Results

Four Level III perinatal centers (designated A, B, C, and D) participated in the study. In total, 151 videos recorded between 2009 and 2015 were available for analysis. Due to the predefined exclusion criteria or poor video quality, 13 videos were excluded, resulting in 138 videos analyzed. Mean total time in the delivery room was comparable at Centers A, C, and D but was one-half that time at Center B (**Table I**). Infants from the 4 centers differed significantly in mean birth weights, gestational ages, rates of cesarean deliveries, and rates of completed course of antenatal steroids (**Table I**).

At all 4 centers, initial treatment started with basic life support measures including drying, wrapping, stimulation, auscultation, applying monitoring, and, if necessary, suctioning. These measures were followed by securing peripheral venous access and inserting a nasogastric tube. Subsequently, the infants were transported to the NICU. Center B did not attempt peripheral venous access. Center D did not insert a nasogastric tube.

At Center C, 8 of 42 infants born preterm were transferred to the resuscitation area in the intact amniotic sac including the placenta. The sac was opened on the resuscitation table, where the umbilical cord was milked and clamped ("En caul delivery").[14]

Table II shows center-specific data on timing and duration of delivery room interventions. Variation between centers was noted for time in the delivery room and in the rate and duration of every intervention (drying, heat protection, rectal temperature, auscultation, stimulation, and suctioning). Methods of thermal regulation varied and included towels (n = 24), transparent plastic wrap (n = 107), metalized wrap (n = 9), and head caps (Centers B and C; n = 76). Wrapping the infant in transparent plastic wrap took 9-19 seconds. Time for wrapping without previous drying varied by 23%-74% at the 4 centers. Oro- or nasopharyngeal suctioning was performed in 83 of 138 (60.1%) infants a total of 227 times. All infants were monitored using a pulse oximeter.

Medical staff at all 4 centers needed >1 attempt to attach the oxygen sensor and to obtain a good plethysmographic signal for monitoring oxygen saturation (SpO_2). Attaching the pulse oximeter took the least amount of time at Center B (12.5 ± 4.1 seconds) and the most time (25.3 ± 11.7 seconds) at Center C ($P < .05$). Time to obtain the first good signal was shortest (23.5 ± 10.6 seconds) at Center B and longest (82.7 ± 120.8 seconds) at Center D ($P < .05$). The time from birth to a reliable SpO_2 signal differed significantly between the 4 centers (**Figure 1**). Attempts to obtain a reliable signal exceeded 60 seconds in 72 (55%) of the infants overall (Center A: 15 [29.4%]; Center B: 9 [16.1%]; Center C: 28 [40.6%]; Center D: 20 [48.8%]). Attempts to obtain a reliable signal exceeded 120 seconds in 21 (16%) of the infants overall (Center A: 7 [28%]; Center B: 1 [2.6%]; Center C: 9 [22%]; Center D: 4 [15.4%]).

Peripheral venous access was successfully obtained in 104 of 138 (75.4%) infants, including all infants at Centers A and D and in 40 of 42 infants at Center C after 1.7 to 2.3 attempts. Time to obtain venous access at each center is shown

Table I. Basic demographic and neonatal characteristics from four European Neonatal Intensive Care Units

Characteristics	Center A	Center B	Center C	Center D	*P* value
Videos, n	37	41	46	27	
Videos included, n	28	41	42	27	
Duration of videos, min, mean ± SD	27.2 ± 6.0	13.2 ± 6.4	25.4 ± 9.0	27.7 ± 7.0	<.05 (B vs A, C, D)
Years of study participation	2013-2015	2009-2014	2011-2013	2009-2013	
Birth weight, g, median (25%, 75%)	1200 (700, 1550)	990 (719, 1240)	1175 (835, 1435)	1323 (971, 1515)	<.05 (B vs A, C, D)
Gestational weeks, median (25%, 75%)	28.4 (26.3, 30.0)	27.9 (26.7, 29.6)	29.3 (26.4, 31.0)	30.3 (28.0, 31.9)	<.05 (B vs C, D)
Sex, male (%)	64	61	45	n.a.	
Apgar scores, median (25%, 75%)				n.a.	
1 min	3.0 (5.0, 8.0)	5.0 (4.0, 7.0)	7.5 (5.0, 8.0)		1′: <.05 (B vs A)
5 min	8.0 (8.0, 8.75)	8.0 (6.0, 8.0)	8.0 (7.0, 9.0)		<.005 (B vs C)
10 min	9.0 (9.0, 10.0)	9.0 (8.0, 9.0)	9.0 (8.0, 10.0)		10′: <.05 (A vs B, C)
Cesarean delivery, %	100	63	100	100	<.05 (B vs A, C, D)
Antenatal steroids (complete course), n (%)	19/28 (68)	33/41 (82)	29/42 (69)	n.a.	<.05 (B vs A, C)

n.a., not applicate because of mode of anonymization approved by the local ethic committee.
Data are shown as numbers or seconds expressed as mean ± SD or median (25% and 75 quartile).

in **Figure 2** (available at www.jpeds.com). Center B did not attempt to obtain peripheral venous access. Umbilical or peripheral arterial or intraosseous access were not performed in the delivery room at any center.

Respiratory support was provided for 132 of 138 (95.7%) infants, excluding 6 infants, (4 at Center A and 2 at Center C). Support was started via face mask in 125 infants (94 during the first minute) and by nasal prongs in 4 infants (Center B only). Three infants at Center C and Center D were immediately intubated without attempting noninvasive support.

Endotracheal intubation was performed in 45 of 138 (32.6%) infants, 2 at Center A, 7 at Center B, 22 at Center C, and 14 at Center D. Eight infants were intubated during the first 5 minutes. The total number of attempts for all centers was 92; the attempts per infant varied by center (Center A: 1.5; Center B: 4.4; Center C: 3.8; Center D: 2.1; $P < .05$). The duration of attempted intubation also varied between centers (**Figure 3**). The duration of intubation attempts exceeded the recommended time of 30 seconds in 92 (83.6%) infants overall (Center A: 4/6; Center B: 32/42; Center C: 26/32; Center D: 30/30).

Respiratory support was interrupted for interventions at all centers 3.5-5.8 times per infant, resulting in a significant difference in total time with no respiratory support (Center A: 49.0 ± 21.2 seconds; Center B: 65.1 ± 29.1 seconds; Center C: 139.4 ± 67.2 seconds; Center D: 104.3 ± 26.5 seconds). A

Table II. Interventions during support of postnatal transition in the delivery room

Interventions	Center A (28)	Center B (41)	Center C (42)	Center D (27)	*P* value
Total time in delivery room, min					
Time/infant	27.2 ± 6.0	13.2 ± 6.4	25.4 ± 9.0	27.7 ± 7.0	<.05 (B vs A, C, D)
Min-max	17.3-43.0	6.4-37.4	11.0-46.8	12.9-44.4	<.05 (B vs A, C, D)
Drying					
Interventions per infant, n	1.2	1.4	1	2.7	
Time per intervention, s	5.0 ± 3.5	7.0 ± 5.7	5.8 ± 3.3	11.1 ± 7.6	<.001 (D vs A, B, C)
Time per infant, s	6.2 ± 3.6	9.8 ± 5.8	5.7 ± 3.3	30.3 ± 7.8	<.001 (D vs A, B, C)
Heat protection					
Transparent plastic wrap, n	27	30	28	22	
Interventions per infant, n	16.2	5.4	10.3	14.1	
Time per intervention, s	6.0 ± 6.9	9.9 ± 10.7	10.1 ± 13.6	8.1 ± 8.1	<.001 (A vs B, C, D)
Time per infant, s	100.5 ± 6.9	53.8 ± 10.6	102.0 ± 13.0	115.0 ± 8.2	<.001 (B vs A, C, D)
Rectal temperature					
Infants, n	28	0	1	20	<.05 (B, C vs A, D)
Interventions per infant, s	2.7	0	1	1.1	<.05 (B, C vs A, D)
Auscultation					
Interventions per infant, s	2.3	3.3	3.4	12.7	
Time per intervention, s	16.2 ± 20.0	18.2 ± 21.7	16.8 ± 19.9	24.9 ± 34.86	<.001 (D vs A, C)
Time per infant, s	37.0 ± 20.1	61.7 ± 21.6	58.2 ± 19.5	316 ± 33.8	<.001 (D vs A, B, C)
Stimulation					
Interventions per infant, s	4.5	1.5	0.4	1.6	
Time per intervention, s	13.6 ± 21.0	13.2 ± 19.9	9.1 ± 6.1	20.6 ± 17.9	<.005 (D vs A, B, C)
Time per infant, s	60.0 ± 20.6	19.7 ± 13.3	3.7 ± 6.1	32.3 ± 18.0	<.05 (A vs B, C, D)
Suction (infants, %)	9 (32.0)	11 (26.8)	36 (85.7)	27 (100)	
Interventions per infant, s	1.2	2.4	3.1	3.0	
Time per intervention, s	7.3 ± 5.7	10.7 ± 8.0	11.0 ± 7.6	8.2 ± 7.3	<.005 (C vs D)
Time per infant, s	8.8 ± 5.6	25.4 ± 7.9	33.6 ± 7.6	24.7 ± 7.2	<.05 (C vs A, D)

Data are shown as numbers or seconds expressed as mean ± SD.

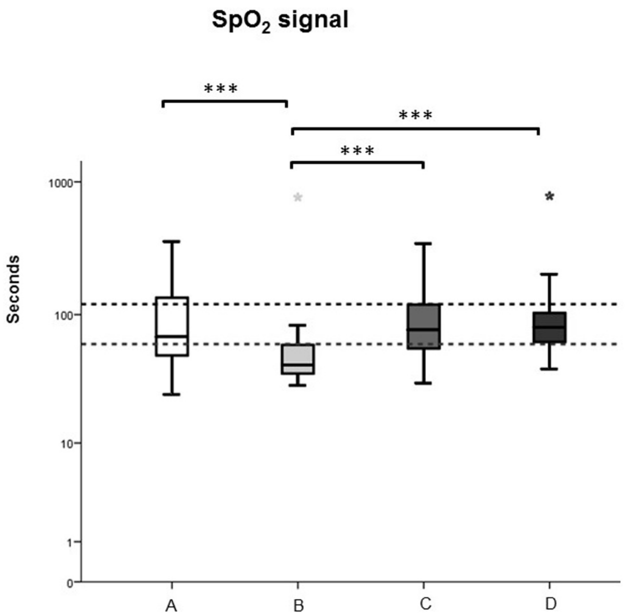

Figure 1. Box plots showing median, IQR, and outliers (*) for obtaining a reliable SpO_2 signal. The Y-axis is displayed in a log scale. Significant differences (***) were noted between Center B and Centers A, C, and D (P < .001). The *horizontal dashed lines* display the time of 60-120 seconds recommended for the procedure.

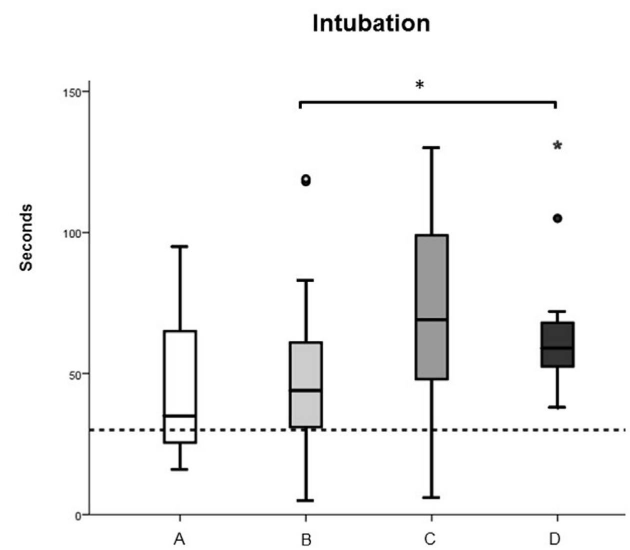

Figure 3. Box plot showing median, IQR, and outliers for duration of intubation attempts. *denotes a significant difference between Center A and Center D (P < .025). The *horizontal dashed line* shows the recommended time of 30 seconds for the procedure.

gastric tube was placed in most infants in the second one-half of delivery room care at Centers A (78%) and C (80%) but not at Center B (5%) or Center D (none).

Absolute time without any medical or nursing intervention varied significantly from 5.4 to 7.5 minutes per infant, (Center B vs D). Center B had the shortest time in the delivery room and the greatest percentage of time with no delivery room interventions (peripheral venous access, intubation, or gastric tube placement; 44.4% vs 27.6%, 26.2%, and 19.6%, P < .05 Center B vs A, C, D).

Discussion

Our video Apgar study of delivery room management of infants with very low birth weight in 3 European countries showed that most interventions vary significantly in time and number within and between the centers. More importantly in our opinion, staff at all centers experienced difficulty acquiring an adequate and sufficient SpO_2 signal and intubating within the recommended time frame (time to achieve a SpO_2 signal by <60-120 seconds, time for endotracheal intubation by <30 seconds).[3,4] The sequence of the interventions was very similar at all centers (**Figure 4**, A-C; available at www.jpeds.com).

Temperature management has become more important in recent years, and early effective temperature monitoring is recommended.[2] A delivery room temperature of 26°C should be maintained[3] to help attain the goal of an infant body temperature of 36.5°-37.5°C. Differences were noted between the centers of our study in rectal temperature measurement. Although Center B did not take any measurements, the number of attempts varied significantly at the other centers. Heat loss prevention by means of a wrap made of a transparent, soft polyethylene film was associated with short but significantly different times for repositioning or interrupting for interventions, eg auscultation, SpO_2 measurement or placing a venous access.

Monitoring of heart rate and oxygen saturation revealed discrepancies with current guidelines, which may have serious implications for infants. All centers used a pulse oximeter placed in a preductal position on the right forearm. However, between the centers, the time to achieve a sufficient signal varied 4-fold, and only Center B achieved a proper monitoring signal within 60 seconds.[2-4] Our data support previous findings, as most SpO_2 signals became reliable within the longer time interval of 90 to 120 seconds.[12,15] It has been shown that pulse oximeter measurements can be subject to some sources of error. For example, application of the sensor first to the infant and then to the oximeter results in less time needed to attain an appropriate signal than does a sensor applied first to the oximeter.[12,16] This delay in placing and reading SpO_2 signals may be alleviated by electrocardiographic monitoring. This is only an optional recommendation in both the European and the US guidelines,[2,3] and it may be faster to assess heart rate, especially in the first minutes. However, it cannot replace the pulse oximeter for assessing oxygenation of the babies.[2]

Respiratory support begins with tactile stimulation of the infant. Center A showed a more aggressive approach to tactile stimulation than did the other centers. Overall, wide variability in stimulation implementation was found within and between the centers. In some cases, stimulation was performed without clinical indication in children with spontaneous breathing and an adequate heart rate. There is no clear recommendation for the type or duration of stimulation,[2-4] but it is to be avoided, especially if spontaneous breathing is already present.[2] Drying the baby usually produces enough stimulation to induce effective breathing.[17] Recent studies of infants born preterm show that tactile stimulation is an important intervention in the postnatal transition.[2,18] In our study, further provision of respiratory support was homogeneous between the centers: face mask, followed by noninvasive ventilation, which changed over time from a nasopharyngeal to a nasal prong approach.

Endotracheal intubation was performed in 45 infants. The number of attempts per infant significantly varied, and none of the centers met the 30-second goal for this procedure[4,13] (**Figure 3**). Intubation is a mandatory key technical and procedural skill in pediatric training.[19] The procedure is more complex in neonates, particularly with lower birth weights. In the literature, success rates vary between 25% and 80%,[13,20-22] with rates as low as 6% in meconium-stained newborns in a recent study.[23] Other recent studies[5,24,25] support our findings that intubation in infants with very low birth weight is difficult. In one study, intubation difficulty (defined as ≥3 attempts) occurred in >15% of infants,[24] and another study showed that intubation could not be completed within the recommended time of 30 seconds in >83% of infants.[25] Even a significant number of formally trained physicians failed to execute this intervention, because they had problems with the appropriate algorithm or technical skills.[20]

These data support mandatory simulation training for technical skills in addition to theoretical knowledge for both physicians and allied professionals,[24-27] as is mandatory under Austrian law.[28]

In addition to the topics discussed, some interventions seem to involve controversial issues, namely some were not performed at all by some centers, but were routine at others, eg, temperature or electrocardiographic monitoring. Some procedures were not typically part of resuscitation algorithms, eg, delayed cord clamping,[29] milking the cord,[30] placement of a gastric tube, venous access, or administration of surfactant.[31,32] At one center, time in the delivery room was significantly shorter and the percentage of no-intervention time was significantly greater because only the most necessary interventions were performed to stabilize the infant for transport to the NICU. Whether this results in reduced stress for the infant cannot be concluded from the video analysis. Also, whether this leads to positive or negative long-term effects is uncertain, as it seems that necessary, complex, and time-consuming interventions are shifted from the delivery room to the NICU.

It is always challenging to make comparisons between centers, as many variables other than birth weight and Apgar scores may have influenced the results. In this study, the center with infants having the lowest birth weight and Apgar scores was fastest at obtaining an appropriate SpO_2 signal and performing endotracheal intubation (**Figures 1** and **3**). Variables that could not be analyzed with a video recording were the level of education and training (consultant vs fellow for intubation; nurse practitioner yes or no), time (day/night; weekend), allocation of resources to the delivery room, or written local standards.[8,24] What becomes clear when comparing all centers is that these advanced technical interventions take considerably more time to perform and administer than expected or recommended.

An important limitation of the study is the study duration and the potential benefit and learning effect from the debriefing and feedback after analyzing the videos.[11] For this analysis, only recordings with sufficient quality were used. Different criteria may be used to analyze videos for other purposes such as respiratory function monitoring. Video recordings make it possible to identify areas for improvement by means of targeted training and are essential for teamwork.[10] It is difficult to say whether the recruited cohort is representative and comparable between centers, as the basic demographic data differed significantly between the centers for gestational age, sex, and Apgar scores. In contrast, the mortality and short-term morbidity data (not shown) were in line with recent literature.[33] Although local policies at all centers recommend cesarean delivery for infants with very low birth weight, a rate of 100% seems unusual and likely reflects that the camera equipment was more readily available at a scheduled times for these deliveries.

Our study showed that neonatal resuscitation procedures provided during the postnatal transition was variable in frequency and duration of delivery room interventions within and between 4 Level III NICUs in 3 European countries. Recommended times for the performance of important, basic interventions such as SpO_2 measurements or for intubation were rarely achieved and may not be realistic. ■

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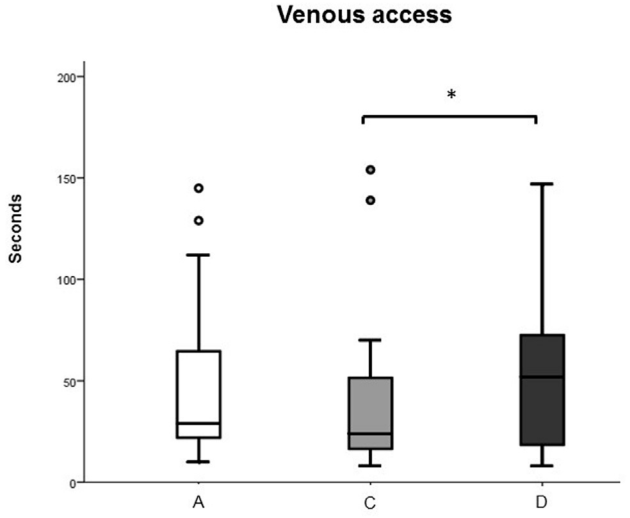

Figure 2. Box plots showing median, IQR, and outliers for venous access attempts. No peripheral venous access was attempted at Center B. A significant difference (*) was noted between Center C vs Center D ($P < .05$).

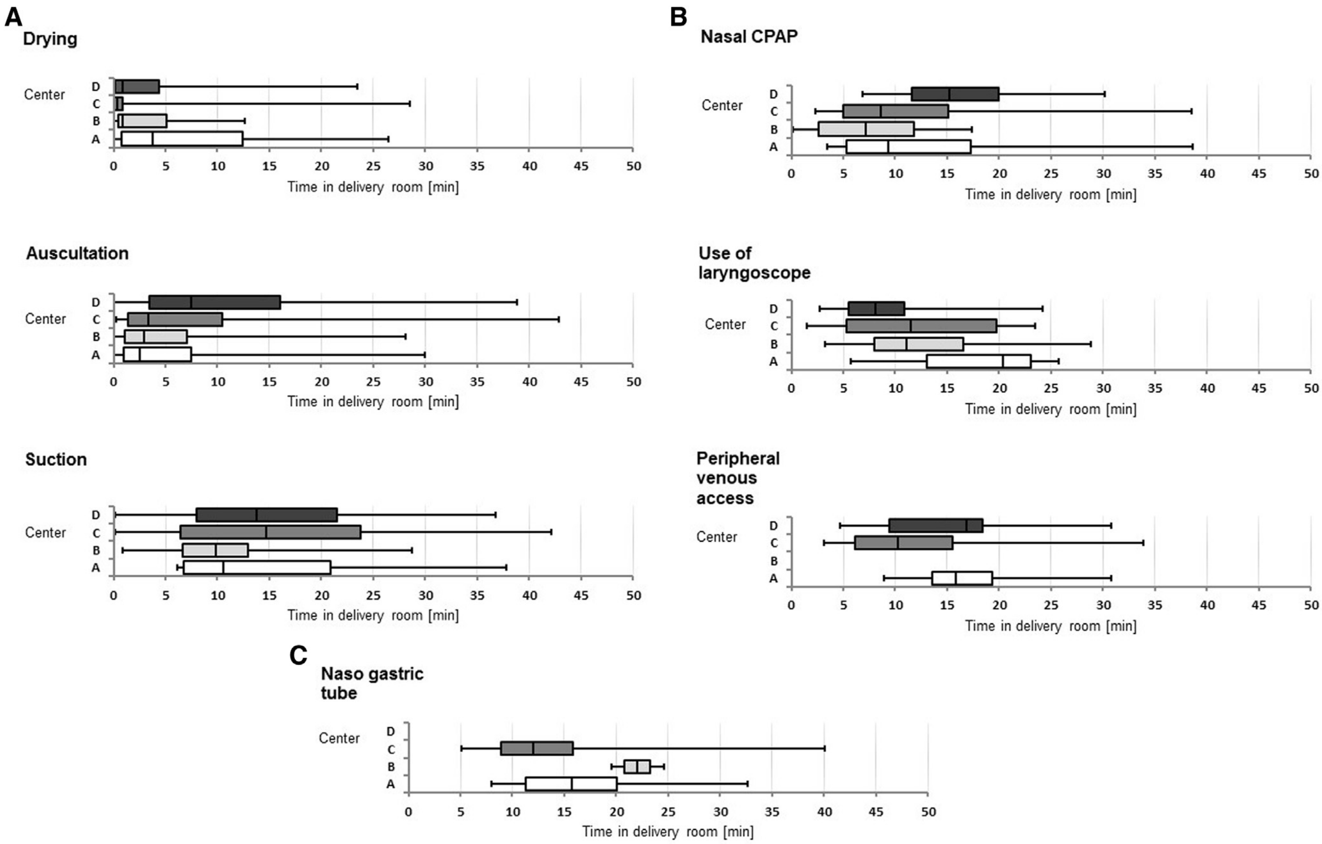

Figure 4. Time of 7 different interventions (panel A-C) with their minimum, median, 25th to 75th percentile, as well as maximum and minimum. The chronology refers solely to the beginning of the particular intervention. Duration and end of the intervention are not shown. If no intervention was performed, no bar is shown for the respective center.