

# A Retrospective Analysis of the Clinical Effectiveness of Supraclavicular, Ultrasound-guided Brachiocephalic Vein Cannulations in Preterm Infants

Christian Breschan, M.D., D.E.A.A., Gudrun Graf, M.D., D.E.A.A., Robert Jost, M.D., Haro Stettner, Ph.D., Georg Feigl, M.D., Stefan Neuwersch, M.D., Christian Stadik, M.D., Markus Koestenberger, M.D., Rudolf Likar, M.D.

## ABSTRACT

**Background:** The aim of this retrospective analysis was to evaluate the clinical effectiveness of the supraclavicular ultrasound-guided cannulation of the brachiocephalic vein in preterm infants.

**Methods:** The ultrasound probe was placed in the supraclavicular region so as to obtain the optimum sonographic long-axis view of the brachiocephalic vein. By using a strict in-plane approach the brachiocephalic vein was cannulated by advancing a 22- or 24-gauge iv cannula from lateral to medial under the long axis of the ultrasound probe under real-time ultrasound guidance into the vein.

**Results:** One hundred and forty-two cannulations in infants weighing between 0.59 and 2.5 kg (median: 2.1; CI: 2.0 to 2.2) were included. Ultimate success rate was 94% (134 of 142). One cannulation attempt was required in 100 (70%) patients, two attempts in 21 (15%), and three attempts in 13 (9%). The smaller the weight of the infant the more attempts were needed. More attempts also were needed for the right brachiocephalic vein, which was primarily targeted in 75 (53%) neonates. One (1%) inadvertent arterial puncture was noted.

**Conclusions:** This supraclavicular, in-plane, real-time, ultrasound-guided cannulation of the brachiocephalic vein seems to be a convenient and effective method to insert central venous catheters in preterm infants. (*ANESTHESIOLOGY* 2018; 128:38-43)

**S**URVIVAL of low-birth-weight newborns increases every day. Some of these babies will require a central venous catheter for parenteral nutrition and for administration of fluids and drugs. Umbilical venous catheters carry a high risk of thrombosis,<sup>1</sup> and peripherally inserted central venous lines in this age group have a small bore, making them inappropriate for blood sampling, high-volume infusions, and monitoring. Therefore, centrally inserted central venous lines may be required. Real-time, ultrasound-guided cannulation techniques have recently enabled fairly safe placements of such lines, even in very small preterm infants, mostly *via* the internal jugular vein (IJV).<sup>2-6</sup>

Another central venous cannulation option mainly performed by anesthesiologists has been the ultrasound-guided supraclavicular cannulation of the brachiocephalic vein (BCV) in infants using the in-plane approach.<sup>7-12</sup>

The primary objective of this retrospective analysis was to evaluate the clinical effectiveness and safety of ultrasound-guided supraclavicular BCV cannulations in low-birth-weight newborns performed at our institution, including puncture complications and the impact of weight on cannulation success. Secondary goals were the comparison of cannulation success between the left and right BCV, the impact of the sonographic appearance of the right BCV on

### What We Already Know about This Topic

- Establishing central venous access in preterm infants is an important aspect of their perioperative and routine clinical care but can be technically challenging

### What This Article Tells Us That Is New

- The supraclavicular, in-plane, real-time, ultrasound-guided cannulation of the brachiocephalic vein is an effective method to insert central venous catheters in preterm infants

cannulation success, and the clinical effectiveness of IJV cannulations if the BCV puncture had failed.

## Materials and Methods

### Background Information

In 2010, the central venous cannulation method at the Pediatric Anesthetic Institute of the General Hospital of Klagenfurt (Klagenfurt, Austria) was changed to the ultrasound-guided supraclavicular in-plane approach of the BCV in all infants. Exclusion criteria for this supraclavicular approach were the inability to visualize the BCV sonographically and any thrombotic formations within the vein. If three attempts to cannulate the BCV failed, the contralateral BCV or the ipsilateral IJV were punctured, the latter

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by using an out-of-plane approach. Since 1994 every central vein cannulation performed by the local pediatric anesthetic team has been documented in individual written central venous catheter protocols at the time of cannulation. These protocols were specifically designed for this purpose and at the time of catheter removal are filed in a Windows Access database (Microsoft Corporation, Redmond, Washington), which was specifically designed for this purpose. Since July 2013, the sonographic image of every central venous catheter placement in a premature infant has in addition been videotaped and recorded.

### Study Population

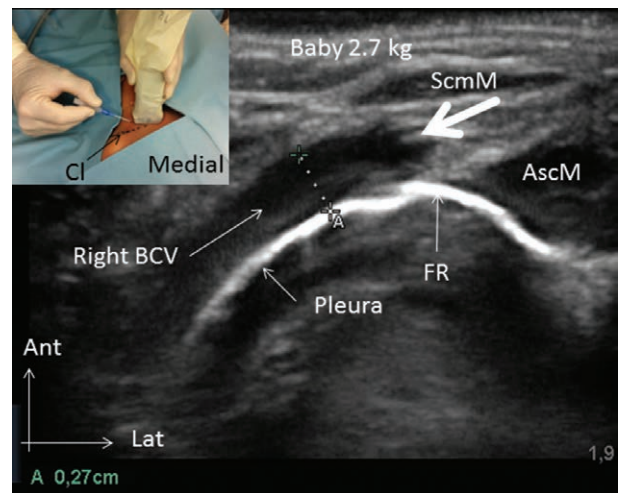
The study was conducted from 2010 to 2016 at the General Hospital of Klagenfurt. After approval by the Ethics Commission of Land Kaernten (Klagenfurt, Austria; Ref: EK07/17), the prospectively collected, computerized protocols of 142 central venous cannulations in preterm infants without major congenital cardiac anomalies and weighing less than 2.5 kg were reviewed retrospectively.

### Protocol for Anesthesia

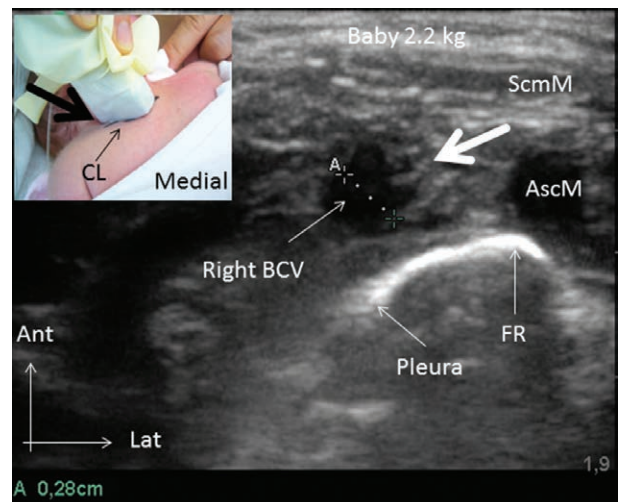
All catheterizations were performed under general anesthesia by three anesthesiologists, one of whom was present as operator or supervisor in almost all cases, including all babies weighing less than 1.5 kg. A standard-sized towel roll was placed under the shoulders. The patient's head was turned 45° to the opposite side.

**Scanning Technique.** An ultrasound device with a 13 to 6 MHz, 25-mm broadband linear array transducer (M-Turbo; Sonosite, Inc., Bothell, Washington), and a depth of 1.9 cm was used. By placing the ultrasound probe perpendicular to the skin at the level of the cricoid cartilage, a short-axis view of the IJV was obtained initially. The probe was then moved caudally following the IJV until the junction of the ipsilateral subclavian vein and the IJV was reached. The probe was then turned slightly medially and tilted behind the clavicle until the optimum sonographic long-axis view of the BCV was obtained (fig. 1). In the case of the right BCV this optimum obtainable sonographic view at times enabled only a circular appearance of the right BCV, presenting just the initial part without demonstrating its path caudally alongside the pleura (fig. 2). Prospective grading of the sonographic appearance of the right BCV in either a sonographic view of the entire long-axis (fig. 1) *versus* just a circular appearance (fig. 2) started in July 2013.

**Protocol for Cannulation.** A 25-mm, 22-gauge (or in the case of a weight less than 1.5 kg, a 20-mm, 24-gauge) iv cannula (Jelco; Smiths Medical International Ltd., Rossendale, United Kingdom) was chosen. Using the in-plane approach, the iv cannula was then advanced from lateral to medial, strictly under the long axis of the ultrasound probe until visualized on the ultrasound screen. The tip of the iv cannula was then guided under real-time ultrasound guidance into the BCV. If the iv cannula could only be located indirectly by tissue



**Fig. 1.** Ultrasonographic view of the entire long-axis of the right BCV in a 2.7-kg infant. *Small picture:* ultrasound probe placed in the right supraclavicular region so as to obtain the optimum long-axis view of the right BCV, iv cannula indicating the direction of cannula insertion. *Ultrasound image:* white, boldfaced arrow indicates iv cannula entry. A indicates diameter of the BCV, 2.7 mm. Ant = anterior; AscM = anterior scalene muscle; BCV = brachiocephalic vein; CI = clavicle; FR = first rib; Lat = lateral; ScmM = sternocleidomastoid muscle.



**Fig. 2.** Ultrasonographic long-axis view of the right BCV presenting a circular appearance as the initial part of the BCV in a 2.2-kg infant. *Small picture:* ultrasound probe placed in the right supraclavicular region so as to obtain the optimum long-axis view of the right BCV. Black, boldfaced arrow indicates the direction of iv cannula insertion. *Ultrasound image:* white, boldfaced arrow indicates iv cannula entry. A indicates diameter of the BCV, 2.8 mm. Ant = anterior; AscM = anterior scalene muscle; BCV = brachiocephalic vein; CI = clavicle; FR = first rib; Lat = lateral; ScmM = sternocleidomastoid muscle.

distortion (as frequently seen in the case of the right BCV when appearing sonographically just as a circle), it was then carefully advanced using its indirect sonographic location as assessed by tissue distortion. If there was a good spontaneous return of blood flow *via* the iv cannula, or if according to the

ultrasound image the tip of the iv cannula was believed to be inside the vein without a spontaneous return of blood flow, the ultrasound probe was turned aside (fig. 3). The needle of the iv cannula was then slightly withdrawn and the cannula fully inserted and blood aspirated. If blood aspiration was successful, it then continued following the Seldinger technique, including a straight 0.018 inch (0.46 mm) guidewire (Arrow; Arrow International, Inc., Reading, Pennsylvania) and a 2-French single lumen catheter (Seldiflex; Plastimed, Saint-Leu-La-Forêt, France). If blood could not be aspirated, the cannulation procedure was regarded as unsuccessful, and the procedure was repeated from the start by piercing the skin again lateral to the long axis of the repositioned ultrasound probe. This was counted as a second cannulation attempt. After three unsuccessful strict in-plane cannulation attempts, we turned to a supraclavicular in-plane cannulation of the opposite BCV, or in cases of unavailability of the opposite BCV, for a central venous line placement we aimed at an out-of-plane cannulation of the right IJV. In these cases, the supraclavicular cannulation procedure of the initially targeted BCV was classified as unsuccessful.

**Choice of Vein.** The choice of initially targeting the right or left BCV was left to the operator unless otherwise determined by medical reasons. From July 2013 on, in order to be familiar with right-sided cannulations as well, the right BCV became the preferred target of the operator performing most of the procedures.

### Data Collection

The following data were prospectively recorded by a written as well as computerized protocol (Windows Access) at the time of cannulation: patient's weight; side (left or right); sonographic appearance of the right BCV, that is, entire long-axis view *versus* circular appearance (beginning in July 2013); number of puncture attempts (one attempt = each

piercing of the skin by the needle or iv cannula) until successful full insertion of the iv cannula into the vein, followed by a positive blood aspiration *via* a syringe; complications, such as arterial puncture, pneumothorax, and hemothorax; iv cannula and central venous catheter material; and the name of the operating physician.

### Statistical Analysis

The Kolmogorov–Smirnov test was used to test the normal distribution of data. Significance was expressed by *P*-value. A *P*-value less than 0.05 was considered statistically significant. Statistical evaluations were performed in R (version 2.7.0, 2008 / version 3.3.2, 2016; The R Foundation for Statistical Computing, <http://cran.r-project.org>), respectively (elementary statistics and figures), in HP-RPL (version 2.08, 2006; Hewlett-Packard Company, USA).

## Results

### Study Population

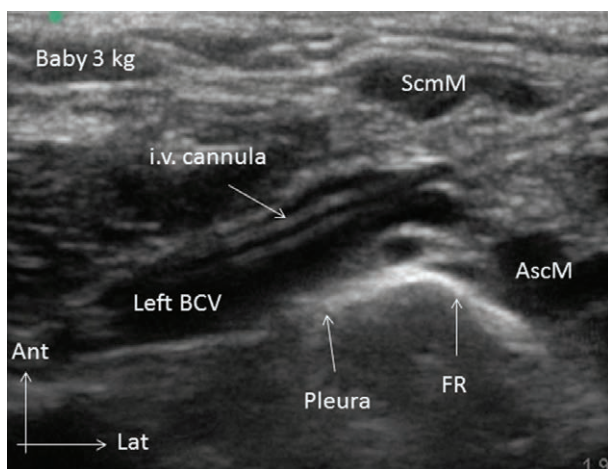
During this 7-yr period, 142 BCVs were cannulated in babies weighing between 590 g and 2,500 g with a median weight of 2.1 kg (95% CI: 2.0 to 2.2). The weight was not normally distributed ( $P < 0.01$ ). The primarily targeted BCV could be identified *via* ultrasound in all babies; in one infant, however, fibrin strands probably caused by a previous central venous line could be identified, so the opposite BCV was chosen. The left BCV was cannulated in 67 cases (47%) and the right one in 75 (53%). One operator performed 130 (92%), another 10 (7%), and yet another 2 (1%) cannulations.

### Cannulation Success

Ultimately successful placement of the central venous line in the primarily targeted vein was 94% (134 of 142). One cannulation attempt was required in 100 (70%) patients, two in 21 patients (15%), and three in 13 patients (9%). In 52 (78%) babies, the left BCV was successfully cannulated on the first attempt, in eight babies (11%) after two attempts, and in five babies (8%) after three attempts. In two (3%) infants at the beginning of the series, three cannulation attempts failed and emergency laparotomy proceeded with the right-sided peripherally inserted central venous lines only in place (table 1).

The right BCV was successfully cannulated on the first attempt in 48 (64%) babies, in 13 (17%) after two attempts, and in eight babies (11%) after three attempts. After three failed attempts to cannulate the right BCV, in four of these six (8%) babies the right IJV was successfully cannulated, requiring one attempt in two babies and two attempts in the remaining two infants (table 1). In two of these six babies, the left BCV was cannulated requiring just one attempt (table 1).

**Complications.** The right subclavian artery was accidentally punctured in one 2.1-kg infant (1%; table 1). In a 1.9-kg baby, the catheter slipped into the contralateral right



**Fig. 3.** Ultrasonographic long-axis view of the left BCV in a 3-kg infant with the 22-gauge iv cannula clearly inside the vein. Ant = anterior; AscM = anterior scalene muscle; BCV = brachiocephalic vein; FR = first rib; Lat = lateral; ScmM = sternocleidomastoid muscle.



**Table 1.** Failed Brachiocephalic Vein Cannulations

BCV	Weight (kg)	Comment
Right	0.7	Poor sonographic view; successful right IJV cannulation on second attempt
Left	0.85	Inadvertent AscM puncture causing a hematoma; proceeded with PICC line
Left	0.67	Inadvertent AscM puncture causing a hematoma; proceeded with PICC line
Right	2.1	Inadvertent subclavian artery puncture; successful right IJV cannulation on first attempt
Right	2.4	Circular sonographic appearance; successful left BCV cannulation on first attempt
Right	2.2	Circular sonographic appearance; successful left BCV cannulation on first attempt
Right	2.2	Circular sonographic appearance; successful right IJV cannulation on second attempt
Right	1.4	Circular sonographic appearance; successful right IJV cannulation on first attempt

AscM = anterior scalene muscle; BCV = brachiocephalic vein; IJV = internal jugular vein; PICC = peripherally inserted central catheter.

subclavian vein as detected *via* ultrasound. The complete cannulation procedure was then repeated successfully.

### Impact of Weight on Cannulation Success

More cannulation attempts were needed for smaller weight babies as also shown by the increasing CI with decreasing weight (table 2).

**Impact of Sonographic Appearance of the Right BCV on Cannulation Success.** In 30 (59%) of 51 babies a sonographic view of the entire long-axis of the right BCV was obtainable as opposed to only a circular appearance in the remaining 21 (41%) patients. In the case of the entire long-axis view of the right BCV, one attempt was needed in 27 (90%) babies, two attempts in two infants (7%), and in one baby all three attempts failed (3%). In the case of only a circular appearance obtainable of the right BCV one attempt was required in nine (43%) babies, two attempts in five (24%), and three attempts in three infants (14%), in addition to four (19%) babies with three failed attempts (table 1).

## Discussion

This investigation of supraclavicular, ultrasound-guided, in-plane BCV cannulations in preterm infants demonstrated a high clinical effectiveness. The eventual success rate was

**Table 2.** Median weight and CI in Relation to Number of Cannulation Attempts

	No. of Patients	Median Weight	Weight 95% CI
One attempt	100	2.2	2.1–2.3
Two attempts	21	2.0	1.9–2.4
Three attempts	13	1.6	1.1–2.4
Three failed attempts	8	1.75	0.7–2.4
Total	142	2.1	2.0–2.2

94%, requiring only one attempt in 70% of cases. One artery injury (1%) was noted. The smaller the weight the more cannulation attempts were needed. The availability of such relatively large bore lines (*i.e.*, 2-French Seldiflex catheters) enabling easy blood aspirations, high-flow infusions, and monitoring can make the difference in terms of morbidity, and maybe even mortality, when these babies undergo major surgery.<sup>13</sup>

The major advantage of this approach is the noncompressibility of the BCV by the approaching needle, its patency even in hypovolemia, and the sonographic real-time observation of the needle advancement over the entire distance. Even if the tip of the cannula cannot be clearly seen *via* ultrasound, as may happen especially with the right BCV, with at times only a circular sonographic appearance obtainable, the tissue distortion caused by the cannula will show its current location so that possible injuries of closely related structures (*e.g.*, aortic arch, carotid artery, and pleura) can be avoided, making it overall a safe approach even in the very tiny neonate.

There is no doubt that in general it is easier to cannulate the left BCV due to its nearly horizontal run as opposed to the caudal extension of the right BCV.<sup>8</sup> As shown again in this analysis, the quick disappearance of the right BCV behind the sternoclavicular joint permits only a circular sonographic appearance as the optimum obtainable view in around one third of the neonates.<sup>7</sup> Then, this in-plane cannulation gets very difficult, as again confirmed by the rather low first attempt success.<sup>7</sup> In this case we might consider in the future turning straight away to either the left BCV if available or to the ipsilateral IJV. As mentioned previously, we had to switch to the out-of-plane cannulation of the right IJV in four failed right BCV cannulations with eventually good results. The major disadvantages of this out-of-plane puncture of the IJV, however, are the virtually invisible needle tip and the complete collapse of the IJV by the approaching needle, making the use of a transfixation technique nearly unavoidable. When going for the IJV we actually attach a 2-ml syringe to a 22-gauge needle (Seldiflex; Plastimed; Saint-Leu-La-Forêt, France) the tip of which we initially push through the IJV centrally *via* the out-of-plane approach, and then we try to aspirate blood only while slowly withdrawing the needle. After good blood aspiration, we introduce the guidewire. It also makes sense to use a slightly more significant neck extension when aiming for the IJV in order to achieve some indirect immobilization of the IJV and also make thus the guidewire insertion more successful. Further disadvantages of IJV catheters have included relatively high catheter associated infection and catheter obstruction rates.<sup>14</sup> No data of catheter-related infections and catheter obstructions exist for the BCV as yet. We also made two noteworthy observations during this investigation. In two tiny babies the anterior scalene muscle was mistaken for the left BCV (table 1). Its inadvertent puncture (in fact, an injury) caused minor hematomas destroying any further sonographic view of the BCV. When taking a look at figures 1 and 2 this mistake can easily happen

as in these tiny infants the anterior scalene muscle looks exactly like a vessel. The best way to avoid this is to follow the scanning pathway accurately as described in the methods section of this paper. Even the use of color flow may easily miss the insignificant blood flow in these tiny vessels. Second, in a 610-g infant we punctured the left BCV successfully on the first attempt; however, blood aspiration was not possible after full insertion of the cannula. So we slowly withdrew the cannula until blood could be aspirated and inserted the cannula then fully upon injecting the aspirated blood. We could probably also have proceeded with the guidewire insertion straight away after the initial successful blood aspiration. Apparently, the tip of the cannula was initially stuck to the wall of this tiny vessel making aspiration of blood impossible. On the other hand, in the smallest included baby, weighing 590 g, full insertion of a 24-gauge iv cannula (Jelco) into the right BCV with an obtainable sonographic view of the entire long-axis was successful immediately (see video, Supplemental Digital Content, <http://links.lww.com/ALN/B530>, which demonstrates the supraclavicular, ultrasound-guided, in-plane cannulation of the right BCV in a 0.59 kg neonate).

A comparison of our data of BCV cannulations with the ones of Montes-Tapia of ultrasound-guided IJV cannulations in preterm infants revealed fewer cannulation attempts for the BCV.<sup>5</sup> This comparison, however, lacks some issues, because they had included more extremely and very low birth weight infants, and they also used up to eight cannulations. Major limitations of this investigation include the retrospective nature and the self-reporting bias. Size measurements of the BCV were not presented because this would have shown erratic values due to the unavailability of a short axis-view of the BCV *via* a linear ultrasound probe.

There is no doubt that in the future more studies, including primarily babies below 1 kg, describing this ultrasound-guided, in-plane cannulation of the BCV will be needed in order to confirm the clinical effectiveness. Long-term complications of these BCV lines including dwell times also will have to be evaluated.

In conclusion, this supraclavicular, in-plane, real-time, ultrasound-guided cannulation of the BCV seems to be a convenient, effective, and more importantly, safe method to insert central venous catheters in preterm infants. The left BCV is easier to cannulate. The sonographic appearance of the right BCV predicts cannulation difficulty. There is no doubt that good training is required. A thorough knowledge of the sonoanatomy is absolutely essential as is the familiarity with the in-plane technique, which also requires good hand-eye coordination.

## Research Support

Support was provided solely from institutional and/or departmental sources.

## Competing Interests

The authors declare no competing interests.

## Correspondence

Address correspondence to Dr. Breschan: Department of Anesthesia, Klinikum Klagenfurt, Feschnigstrasse 11, 9020 Klagenfurt, Austria. [breschan.ch@chello.at](mailto:breschan.ch@chello.at). Information on purchasing reprints may be found at [www.anesthesiology.org](http://www.anesthesiology.org) or on the masthead page at the beginning of this issue. ANESTHESIOLOGY's articles are made freely accessible to all readers, for personal use only, 6 months from the cover date of the issue.

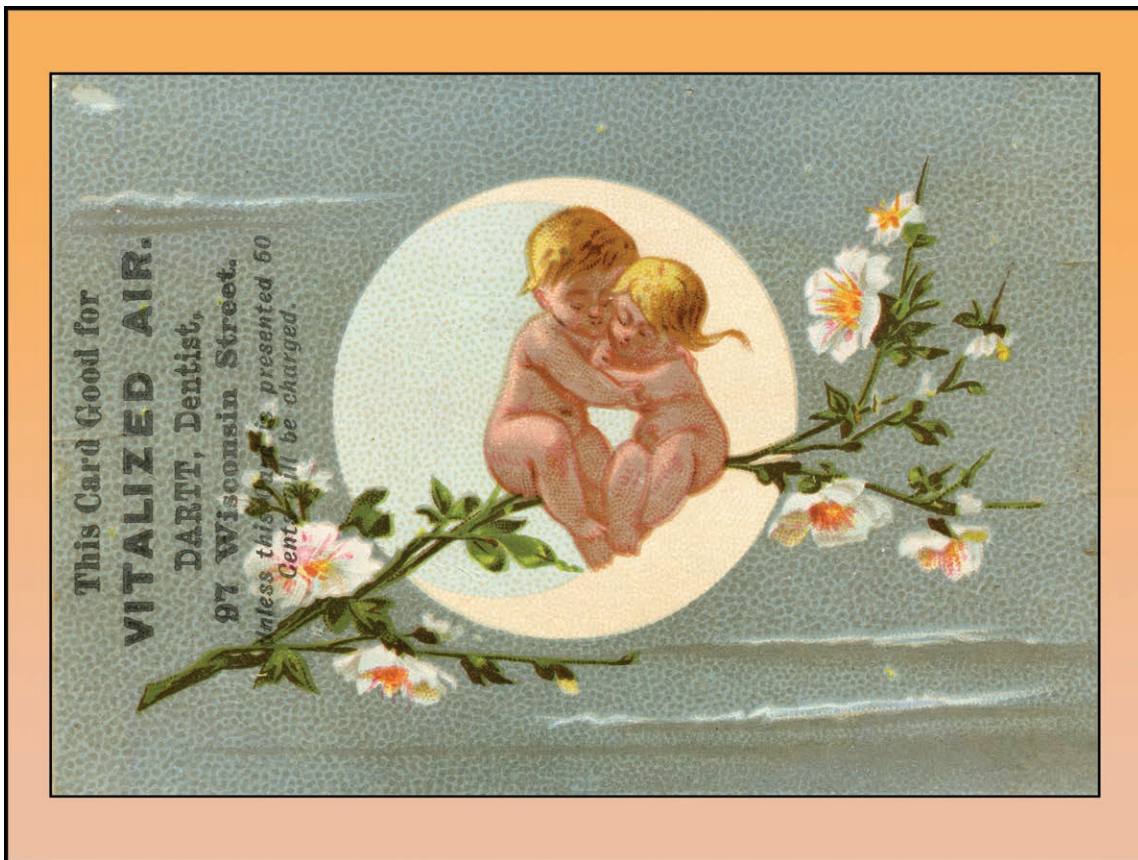
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### Embracing Vitalized Air...with a Coupon: Dr. W. A. Dartt of Milwaukee



From a trade card of Dr. William Allen Dartt (1852 to 1917), the obverse (*above*) depicts two sleepy cherubs embracing in the moonlight as they balance precariously on a flowering sprig. The overprinting states, "This Card Good for VITALIZED AIR.... Unless this card is presented 50 Cents will be charged." After writing his thesis on "Gold for Fillings" for his 1876 D.D.S. degree from the Philadelphia Dental College, Dartt struck gold again as Milwaukee's leading advertiser of "vitalized air" anesthesia (nitrous oxide adulterated by a trace mixture of ethyl alcohol with chloroform). Milwaukee city directories listed Dr. Dartt as practicing at this "97 Wisconsin Street" address from at least 1885 to 1886. (Copyright © the American Society of Anesthesiologists' Wood Library-Museum of Anesthesiology.)

George S. Bause, M.D., M.P.H., *Honorary Curator and Laureate of the History of Anesthesia*, Wood Library-Museum of Anesthesiology, Schaumburg, Illinois, and Clinical Associate Professor, Case Western Reserve University, Cleveland, Ohio. [UJYC@aol.com](mailto:UJYC@aol.com).