



## Anesthesia | Ventilation performance



**Flow-i helped save  
a 393 gram neonate**

Premature infant weighing only 393 g, successfully anesthetized and ventilated with the Flow-i anesthesia machine.

*Photo reprinted with permission of the child's parents.*

# Delivering small volumes with precision

– key to a successful outcome

In pediatric anesthesia, while caring for patient ranges from the tiny newborn to the obese teenager, a wide variety of equipment in different sizes is required. Regarding the anesthesia machine, it is important to have access to “a system capable of delivering even small volumes while supplying with precision inhalation gases” (Lönnqvist).

## Case report

A 39-year-old woman became pregnant with twins after in vitro fertilization. The pregnancy was difficult: the mother-to-be needed a cerclage (week 18), was an inpatient for suspicion of amniotic infection syndrome (week 20) and received steroids for lung maturation (week 23). One of the babies died in utero in week 23 with trisomy 18. With the worsening of the Cardiotocography (CTG), along with a falling heart rate, the decision was made for a cesarean section at the gestational age of 23 weeks + 3 days. The delivered baby was an extremely immature, cyanotic, floppy, and small-for-date preterm girl, weighing 355 g. She required resuscitation with intubation following positive pressure mask-ventilation.

After stabilization of vital parameters, sedation with Midazolam and Nalbuphine was started and the baby was transferred to the neonatal intensive care unit (NICU). Further examination revealed an anal atresia with a fistula. Coexisting anomalies could not be found in the remaining organ screening. The fistula could be probed with a Fr/CH 4 size gastric tube and meconium was found. First day of nonmeconical stool deposits was on day 7 and onwards, so surgery was not an option at this time.

After 4 days on catecholamines the baby was stable with hemodynamic parameters. Surfactant was applied in summary 3 times, she received antibiotics, resulting in a



stable pulmonary and ventilatory situation. Packed red cells were transfused. Repeated cranial sonographies did not show any intraventricular hemorrhage (IVH). Enteral feeding was done very cautiously, but was possible.

## Worsened conditions on day 11

On day 11, the general condition worsened considerably with clinical and radiological signs of an ileus. It was possible to probe the fistula with Fr/CH 6–8, however, the baby did not deposit any more feces. The clinical investigation showed a raised and stretched abdomen which was sensitive for touch, and spastic intestinal convolutions could also be observed. From the abdominal X-ray, a massively extended loop in the right lower abdomen was

identified. Free intra-abdominal air or outflow of contrast media could not be excluded. The laboratory examination showed increasing leucocyte values—the remaining parameters were mostly unremarkable. The respiratory situation got worse and, to secure oxygenation, the inspired oxygen fraction had to be raised constantly to more than 0.4. To achieve adequate gas exchange the peak inspiratory pressure had to be increased to 22–24 mbar (see Table 1).

Table 1

PIP (peak inspiratory pressure)

Laboratory examination	2nd day	3rd day	7th day	10th day	11th day
Leucocytes (G/l)	17.85	34.97	15.2	29.5	34.63
Hemoglobine (g/dl)	12.9	13.0	13.8	14.1	13.1
Thrombocytes (G/l)	209	153	101	156	200
CRP (mg/l)	<0.6	<0.6		<0.6	
<b>Respiratory situation</b>					
F <sub>I</sub> O <sub>2</sub>		0.23–0.4			>0.4
PIP (mbar)		18			24

After considering everything, the decision was made for urgent explorative laparotomy under suspicion of mechanical obstruction or intestinal perforation.

The anesthesiological assessment revealed the before mentioned medical history. The family history did not suggest any malignant hyperthermia susceptibility. The patient was hemodynamically stable without any circulatory support. An actual cranial sonography did not show any intraventricular hemorrhage (IVH). She was intubated and ventilated under sedation with Midazolam and

morphine and a preoperative antibiotic treatment with Meropenem and Teicoplanin had already been started.

Her weight on the day of surgery was 393 g. She was intubated with an endotracheal tube size 2, and had one intravenous line (i.v.) G 26 and a gastric tube Fr/CH 4. She received additionally two peripherally inserted i.v. lines — one of them was used postoperatively to insert a central venous line (G27) — and a urinary catheter Fr/CH 4. The temperature was taken from the skin; to warm the infant, a convective, air-warming blanket was used.

The intraoperative situs showed a narrow anal fistula to be the cause of the ileus. Fortunately, there weren't any signs of necrotizing enterocolitis. The colon was relieved, stool and air sucked and an ileostomy was made. Also, a large Meckel diverticulum was found and removed.

A balanced anesthesia with Sevoflurane (et vol% 1.8–3), Fentanyl (bolus 3.8 µg/kg; 2.5 µg/kg/h) and S-Ketamine (bolus 1.5 mg/kg; 1.5 mg/kg/h) was used without any muscle relaxants. The baby was given a glucose infusion intra-operatively, corresponding to 0.7 mg glucose/kg/min, with blood glucose values within the normal range (92–97 mg/dl).

The fluid and volume management consisted of crystalloids as glucose and isotonic solutions. As colloids, she received fresh frozen plasma and packed red cells. In summary, it was an equivalent of 20 ml per kilogram an hour during the 3-hour operation (with Na 138–144 mmol/l; Hb 11.4–12.7 g/dl).

The girl was stable throughout the operation with her vital parameters: heart rate about 110–130 per minute, which was about 20% below her non-anesthetized values. The blood pressure was within the normal range for her age mean arterial pressure 25–46 mmHg). There was urinary production in an adequate way (3.6 ml/kg/h). Oxygenation was not a problem (SO<sub>2</sub> 91–95%) with low inspired oxygen fraction (FiO<sub>2</sub> 0.25–0.31). Temperature was acceptable intra-operatively (36–37.8°C).

The respiratory course was surprisingly simple without any problems, neither with the girl's lungs nor the Flow-i and disturbing alarms. On the contrary, the intensity of the respirator settings adopted from the intensive care respirator could be reduced before skin incision and opening the abdominal wall (see Table 2).

Table 2

	PIP (mbar)	PEEP (mbar)	MV (l/min)	RR (/min)	TV (ml)	FiO <sub>2</sub>	pH	P <sub>cap</sub> O <sub>2</sub> (mmHg)	P <sub>cap</sub> CO <sub>2</sub> (mmHg)	HCO <sub>2</sub> (mmol/l)	BE (mmol/l)	etCO <sub>2</sub> (mmHg)
Intensive care resp	22	4	0.08	28	2.9	0.35	7.4	30	47	27.1	4.2	n.m
FLOW-i (PCV)	14	5	0.07	24	3	0.31	7.35	48.9	46	26	0.4	34

BE: base excess  
 cap: capillary  
 etCO<sub>2</sub>: endtidal CO<sub>2</sub>.  
 MV: minute volume  
 n.m.: not measured  
 PEEP: positive end expiratory pressure  
 PIP: peak inspiratory pressure  
 PCV: pressure controlled ventilation.  
 RR: respiratory rate  
 TV: tidal volume

The measurement of even the smallest breath volumes was very reliable and reproducible throughout the operation while observing adequate chest movements. With minimal leakage from the endotracheal tube there was a rather good correlation between end-tidal (et) and capillary (cap) CO<sub>2</sub> values (see Table 3).

Table 3

	50 min. after taking over	150 min. after taking over	280 min. after taking over
PIP (mbar)	14	14	14
PEEP (mbar)	5	5	5
MV (l/min)	0.1	0.07	0.07
TV (ml)	4	3	3
FiO <sub>2</sub>	0.31	0.29	0.28
etCO <sub>2</sub> (mmHg)	34	44	43
P <sub>cap</sub> CO <sub>2</sub> (mmHg)	48	46.5	50.3
pH	7.35	7.35	7.27
P <sub>cap</sub> O <sub>2</sub> (mmHg)	48	46.4	51.4
HCO <sub>3</sub> (mmol/l)	26	24.8	22.1
BE (mmol/l)	0.4	-0.9	-4.7



Postoperatively, the baby was transferred to the NICU, intubated and ventilated without any circulatory support and in stable conditions. The further course was fortunately uncomplicated and the girl was extubated on her 37th day of life, weighing almost 600 g. On day 80 oxygen therapy could be stopped, two days later she passed the 1000 g border. The closure of the ileostomy was done when she reached more than 2 kg in weight, and the child was discharged home on her 166th day of life. An anoproctoplasty operation was performed at the corrected age of 13 months. So far, at the corrected age of 25 months with 10 kg body-weight, she is an open-minded, bright girl with little developmental delay.

### Summary

Unproblematic anesthetic course in a challenging patient at the extremes of age (GA 23 +3/7 weeks; 11th day) and weight (393 g), successfully and considerably ventilated and anesthetized with Flow-i — a pleasant outcome during the most recent follow-up at the age of 25 months.



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