Editor's key points

- The Neonatal Resuscitation Program (NRP) provides instruction for health care practitioners in the event of cardiorespiratory distress in neonates. However, there are cases in which the neonate does not respond to these interventions and is in shock that does not respond to NRP, requiring other treatments.
- In the event of NRP-unresponsive shock, quickly follow *VEB* to determine and correct the cause: *validate* observations (ie, using an electrocardiogram), *escalate* intensity of interventions and calls for help (ie, enlisting the assistance of another department), and *broaden* diagnostic considerations to rule out differential diagnoses.
- The differential diagnoses for regular narrow-complex tachycardia include sinus tachycardia and supraventricular tachycardia.

Points de repère du rédacteur

- Le Programme de réanimation néonatale (PRN) offre aux professionnels de la santé des instructions à suivre en cas de détresse cardiorespiratoire chez un nouveau-né. Toutefois, dans certains cas, le nouveau-né ne répond pas à ces interventions et est dans un état de choc qui ne réagit pas au PRN, et nécessite d'autres traitements.
- Dans l'éventualité d'un choc qui ne répond pas au PRN, il faut procéder rapidement au *VEB* pour déterminer et corriger la cause : *valider* les observations (p. ex. à l'aide d'un électrocardiogramme), *élever* l'intensité des interventions et des appels à l'aide (p. ex. solliciter l'assistance d'un autre département) et *bonifier* les considérations diagnostiques pour exclure les diagnostics différentiels.
- Les diagnostics différentiels pour une tachycardie à complexe étroit et rythme régulier incluent la tachycardie sinusale et la tachycardie supraventriculaire.

Shock unresponsive to Neonatal Resuscitation Program interventions

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The Neonatal Resuscitation Program (NRP)[1] provides excellent guidance for family physicians, pediatricians, nurses, and midwives treating neonates exhibiting cardiorespiratory compromise in the transition immediately following birth. Most such neonates respond well to the primary interventions of NRP, which include oxygenation, ventilation, and administration of intravascular fluids or epinephrine. Occasionally, as illustrated by the case, a neonate may unexpectedly remain critically unstable despite these interventions. An uncommon etiology may be responsible for such instances of shock, so treatments outside the scope of the NRP may be required. It is vitally important to have a rapid, effective approach when treating critically ill patients with shock that does not respond to NRP interventions.

Case presentation

A newborn boy was delivered vaginally with vacuum assistance at 39 weeks and 5 days' gestation to a 32-year-old primigravida woman. There had been no prenatal concerns other than prolonged rupture of membranes (31 hours) and diet-controlled gestational diabetes. During the last 10 minutes of labour, fetal heart rate monitoring showed prolonged variable decelerations to 90 beats/min, with slow recovery to a baseline of 180 beats/min and overshoots to 210 beats/min.

A nuchal cord was clamped and cut. The neonate was noted to have very poor tone and respiratory effort, and obvious pallor. Following the NRP,[1] he was immediately repositioned and suctioned, and positive-pressure ventilation was attempted. When ventilation-optimizing maneuvers were not immediately successful, he was promptly intubated; endotracheal placement was confirmed by auscultation and carbon dioxide detection.

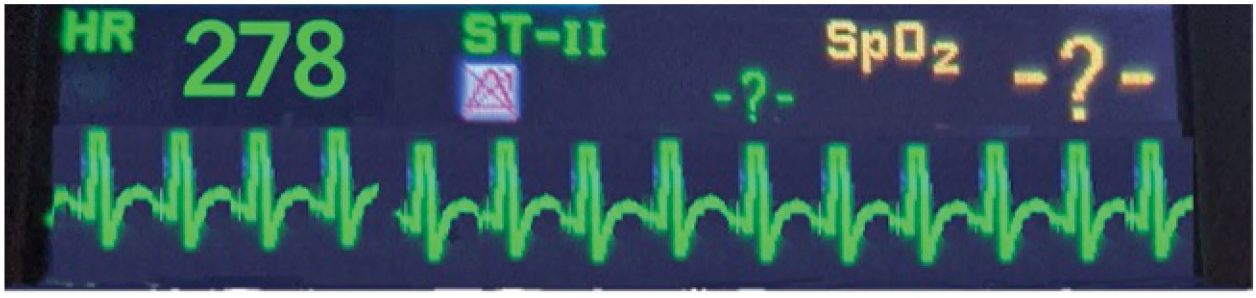
The heart rate was assessed next and found to be greater than 100 beats/min, but pulses were weak and thready. The patient remained unresponsive with signs of poor perfusion (pallor, capillary refill greater than 4 seconds) and absent muscle tone. A pulse oximeter on the right wrist persistently detected no usable signal. The cause of the patient's shock was not immediately apparent. The NRP highlights hypovolemia and pneumothorax as causes of persistent bradycardia with poor perfusion, but provides little guidance on instability in patients with a heart rate greater than 100 beats/min.[1] Fortunately, in our case, an electrocardiogram (ECG) was requested, which revealed a pivotal finding (**Figure 1**).

Discussion

Differential diagnoses. The ECG showed regular narrow-complex tachycardia with a ventricular rate of 278 beats/min. The differential diagnoses included sinus tachycardia and supraventricular tachycardia (SVT).[2] The possibility of a monitor error was also considered (eg, miscounting T waves as QRS complexes, erroneously doubling the ventricular rate).

Features of SVT include the following[2]: ventricular rate greater than 220 beats/min in infants (180 beats/min in children); abrupt onset and termination of tachycardia episodes; absent or abnormal P waves (may be difficult to discern at rapid rates); no variability beat to beat (ie, R-R interval and ventricular rate remain exactly fixed over time and do not vary, even by a few beats per minute);

Figure 1. Neonate electrocardiogram showing regular narrow-complex tachycardia (reconstruction)



and signs of congestive heart failure (eg, rales, hepatomegaly, edema) in SVT of longer duration. Sinus tachycardia exhibits the opposite of each of the features listed.

Sources of information. The PubMed database was searched using the terms *neonate*, *supraventricular tachycardia*, *resuscitation*, and *delivery*. Relevant articles, their references, and standard resuscitation manuals were reviewed.

Supraventricular tachycardia. An acute episode of SVT arising immediately during this neonate's transition to extrauterine life led to tachyarrhythmia-induced cardiogenic shock unresponsive to standard NRP interventions.

The mechanism underlying SVT is a re-entrant atrioventricular or nodal accessory pathway, the latter being uncommon before 2 years of age.[3] Reduced cardiac output during an episode can result from shortened ventricular filling time and tachycardia-induced myocardial dysfunction, among other factors.[4] A study observed an incidence of SVT of approximately 0.6% in neonatal intensive care unit patients[5]; the condition is not always detected antenatally. Underlying structural cardiac abnormalities may be absent.[4] The literature review revealed no other reports of SVT presenting immediately at birth. However, the NRP recommendation to use ECG monitoring may facilitate the identification of cardiac arrhythmias in this period. The Heart and Stroke Foundation of Canada guidelines[2] for Pediatric Advanced Life Support dictate that for an infant with SVT with poor perfusion and cardiopulmonary compromise despite optimized oxygenation and ventilation, immediate synchronized cardioversion is indicated at a dose of 0.5 to 1.0 J/kg if adenosine bolus (0.1 mg/kg intravenous or intraosseous infusion) is unavailable or ineffective. Vagal maneuvers (eg, cold stimulus to the face) may be considered but should not delay adenosine bolus or cardioversion.

Case resolution

To concurrently identify and treat alternative causes of this neonate's pallor and potentially refute the presumptive diagnosis of SVT, the patient's hemoglobin concentration was measured (126 g/L) and 0.9% sodium chloride was administered (total 20 mL/kg). The heart rate remained unchanged at precisely 278 beats/min throughout, providing further confirmatory evidence of SVT. Preparations were made for cardioversion, but a neonatology consultant advised applying a vagal stimulus (ice pack to the patient's forehead). Within seconds, the ECG showed conversion to sinus rhythm at a rate of 160 to 170 beats/min. His colour, perfusion, respiratory effort, and neurologic signs improved promptly and dramatically. The neonate was monitored during his 8-day stay in a regional neonatal intensive care unit, and there was no recurrence of tachyarrhythmia. Therapeutic hypothermia and oxygen supplementation were provided for signs of moderate hypoxic-ischemic encephalopathy and pulmonary hypertension, respectively. The patient has since recovered.

Conclusion

When faced with shock unresponsive to NRP interventions, it is helpful to follow *VEB* (**Table 1**)[1]: *validate* information (in our case, we reconfirmed heart rate via ECG monitoring), *escalate* calls for help and intensity of interventions (eg, use of cardioversion), and *broaden* diagnostic considerations (even after normal pregnancy and birth) (**Box 1**[1,2]).

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Competing interests

Dr Andre Jakubow is an instructor for Neonatal Resuscitation Program courses with the Canadian Paediatric Society (CPS) and Pediatric Advanced Life Support courses with the Heart and Stroke Foundation of Canada (HSFC). The opinions expressed in this article are those of the author and do not necessarily reflect those of the CPS and HSFC.

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Table 1. The *VEB* approach to NRP-unresponsive shock: ***In addition to standard NRP procedures, the following may be attempted with appropriate judgment.***

	VALIDATE **(RECONFIRM) INFORMATION**	***ESCALATE*** **(INTERVENTIONS AND CALLS FOR HELP)**	***BROADEN*** **(DIAGNOSTIC AND THERAPEUTIC CONSIDERATIONS)**
Airway and breathing	Ensure that end-tidal carbon dioxide, bilateral breath sounds, and chest rise are definitely present; most neonatal instability is caused by inadequate ventilation[1]	Escalate to endotracheal tube insertion if appropriate, especially if doubt exists regarding the proper functioning of supraglottic airway device[1]	If deterioration occurs postintubation, consider DOPE mnemonic (displacement, obstruction, pneumothorax, equipment failure)
Circulation	Ensure ECG is monitored[1] and blood pressure is measured (if relevant)	Consider treating hypovolemia by administering a crystalloid bolus (10 mL/kg)[1]	Consider broader possible etiologies of shock (**Box 1**[1,2])

ECG—electrocardiogram, NRP—Neonatal Resuscitation Program.

Box 1. Etiologies of shock and corrective actions

Hypovolemic or hemorrhagic
- Seek history of bleeding
- Check hemoglobin (values may be falsely normal in acute hemorrhage)
- Consider transfusion

Obstructive
- Tension pneumothorax[1]
  - -Assess breath sounds, symmetry, transillumination, and ribs; evacuate using NRP techniques if indicated
- Ductus-dependent lesion[2]
  - -Review prenatal imaging
  - -Consider alprostadil infusion (consultation advised)
- Pericardial tamponade[2]
  - -Pericardiocentesis (rare)
- Pulmonary embolism[2]
  - -Anticoagulation or thrombolysis (rare)

Cardiogenic
- Arrhythmias: treat according to PALS guidelines[2]
- Contractility: consider inotropic support[2]

Distributive, septic, or neurogenic
- Treat using fluids, vasoactive agents, or antibiotics

Other
- Reversible causes of cardiac arrest (*H*s and *T*s) as per PALS guidelines[2]
  - -Hypovolemia, hypoxia, hydrogen ion (acidosis), hypoglycemia, hypokalemia or hyperkalemia, and hypothermia
  - -Trauma, toxins, tension pneumothorax, tamponade (cardiac), and thrombosis (pulmonary or coronary)
- ECMO or CPB may be considered in rare instances in specialized settings

CPB—cardiopulmonary bypass, ECMO—extracoporeal membrane oxygenation, NRP—Neonatal Resuscitation Program, PALS—Pediatric Advanced Life Support.