ANET 2.0

In order to operate the complete exchange transfusion setup with little to no human involvement, our predecessors did wonderful work by birthing the concept of Automated Neonatal Exchange Transfusion (ANET) 2.0 which combined mechanics, electronics, and programming. This was accomplished using the following methods:

This was accomplished using the following methods: A push and pull segment made up of a bipolar stepper motor, a lead screw, and guiding rods were employed to accomplish this function. The clockwise rotation of the stepper motor. The threaded rod moves in that direction as the motor rotates counterclockwise to provide a sucking action. The physicians' manual blood drawing and delivery procedures were replaced by this system. This innovative method for switching valves that use motors driven by software that will be built for the microcontroller to replace the manual switching of valves. The project synchronizes the push-pull segment and the valve control segment to carry out the procedures of blood withdrawal and donor blood replacement.

Two unipolar stepper motors, two three-way valves connected in series, and a catheter end attached to the infant, the waste container, and the donor blood bag made up the valve-switching system utilized in ANET 2.0.

The three-way valves that are employed in this system, however, had to be manipulated by human hands, which presented an issue for connecting the motors with them.

ANET 3.0

The work of the automated Neonatal Exchange Transfusion version 3.0 looked at the flaws of the existing ones from ANET 1.0 and 2.0. Their objective was to also pick up from our predecessors and make the Neonatal Exchange Transfusion an automated one as well.

They combined mechanics, electronics, and programming to achieve this.

The design of the device was a little bit different because most of the parts were 3D printed and used for the purpose without building it from scratch.

The three-way valve was manipulated by another motor in this case so the physician wouldn’t have to control it. The device was further used to test on animal lab subjects on the exchange transfusion.

Aside from these positive breakthroughs that ANET 3.0 was able to make it had some challenges.

The valve was rotating as well as moving the handle as well, the intended purpose was for it to rotate on its own so friction is not generated. As a result of this, excess heat was generated and the device was working after a while.

Also, the push and pull block had a very rigid sense of motion in plunging.

COMPLICATIONS OF EXCHANGE TRANSFUSION

Exchange Transfusion is regarded as a safe and successful treatment, (1)it is not without risk(refer to Table 4) According to a study conducted by (2,6), it was observed that the process can result in the death of neonates as well. The current guidelines for doing an exchange transfusion are based on a balance between the risks of encephalopathy and the problems linked to the treatment. Its death rates range from 0.5% to 3.3% (3). But, if the process is done extremely carefully and bilirubin levels are consistently monitored(5), with the appropriate hygiene, and care, the majority of these issues may be avoided. Typically, pausing or slowing down the trade is the best way to handle these issues (4).

|  |  |
| --- | --- |
| Complications during the procedure | Complications after the procedure |
| Air Embolus | Infection |
| Volume Imbalance | Thrombocytopenia |
| Hyperkalaemia | Hypoglycaemia |
| Arrhythmias | Blood transmitted infections |
| Respiratory Distresses | Hypocalcaemia |
| Anaemia/ Polycythaemia | Anaemia/ Polycythaemia |
| Acidosis | Hypernatremia |

|  |  |  |
| --- | --- | --- |
| **DONOR BLOOD** | **INFANT COMPLICATION** | **PREVENTION/TREATMENT** |
| Old blood (high K+, low platelets) | Hyperkalemia, thrombocytopenia | Use blood less than 5 days old. Monitor ECG during and after procedure. Watch for signs of bleeding |
| Citrate blood | Hypocalcemia and hypomagnesemia | Consider 1-2 mL kg-1 of calcium gluconate after 50-100 mL of blood exchange in sick infants. Monitor serum calcium 2 h after an exchange. In case of unexplained arrhythmia use 2 ml/kg of 10% calcium gluconate infusion |
| Cold | Hypothermia | Prewarm the blood. |
| High glucose | Rebound hypoglycemia | Check blood glucose 2 hours after exchange transfusion. Initiate early enteral feeds |
| Glucose 6-phospho dehydrogenase deficient | Increased hemolysis, rebound hyperbilirubinemia | In endemic areas screen for glucose 6-phospho dehydrogenase status of donor blood |

BLOOD VOLUME CALCULATIONS

The difficulty in calculating the amount of exchange blood needed for newborns is related to how much blood is needed to raise their hemoglobin levels to an acceptable level. Nonetheless, a formula has been developed based on the supposition that the rise in hemoglobin

Throughout the operation, concentration is a linear function of volume exchange (7). The early stages of the blood exchange are when the change in hemoglobin concentration is largest, and it gradually decreases as the blood is exchanged. The total volume of the cells and plasma in the circulatory system is what we refer to as blood volume (8,9). The dilemma of whether or not the techniques for calculating plasma and cell volume include or omit these extravascular components immediately emerges because all components of the blood, including created elements, are to some extent present outside blood arteries. (8,9)

The general exchange volume parameter is given as:

The product of the total volume to be delivered and the weight of the baby which is all divided by 1kg.

Mathematically expressed as:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Weight | Exchange Volume | Total Volume of Blood |
| Preterm |  |  |  |
| Term |  |  |  |

According to Table 2 above, during the exchange operation, 200 ml and 320 ml of fluid will be given to preterm and term newborns, respectively. The exchange volume parameter provides the foundation for this computation.To calculate the number of cycles and the duration that the process will last, the formulars below are used:

Single

The baby’s blood volume is the same as the amount of the blood volume we estimate.

For instance, just 80ml/kg of blood volume would be needed to do a single-volume transfusion on a term. This method substitutes 60–65% of the baby's red blood volume.

Preterm or term babies mostly in the example table above are given a total of 320ml and 200ml during the exchange procedure.

Double

 Double Volume Exchange Transfusion involves repeating the single volume exchange transfusion. The blood to drawn from the neonate is estimated to be twice the baby's blood volume in circulation.

 The blood to drawn from the neonate Between 85-88% of the baby's red blood cells or blood volume are replaced.

The end part of this process is most popular and mostly used to treat newborns with chronic jaundice (hyperbilirubinemia)

 The efficiency of the double volume exchange transfusion should have been twice as high as the single volume exchange transfusion, one may have predicted.

Yet this is not the case. Just a 25% average gain in efficiency is observed (i.e. from 80 to 85).

Nearly all of the baby's blood's circulation cannot be exchanged. This occurs as a result of circulation mixing the baby's blood with the blood flowing in. The double volume exchange transfusion is best when efficiency is compared to the total amount of blood that is circulated since it minimizes waste by using less time, energy, and resources while maintaining high efficiency.

The amount of blood exchanged as an aliquot depends on the weight of the infant. This is due to the fact that, depending on the weight of the infant, if more blood than a specific quantity is withheld, the child may lose consciousness or have organ failure. As a result, the following criterion is used to determine how much blood should be exchanged during a cycle.

Due to the circumstances surrounding the infant, the doctor may not strictly adhere to this and instead utilize quantities that are lower or higher.

In light of everything that has just been discussed, take into account the following: noting that the infant will get an exchange transfusion:

A premature infant with a mass of around one kilogram.

As the infant is premature, the standard quantity of blood exchange is around 200 ml per kilogram of the infant. By dividing this statistic by the baby's weight, we can determine the total volume of blood that has to be exchanged. 𝑖.𝑒. 200𝑚𝑙𝑘𝑔 ×1.0𝑘𝑔 =200𝑚𝑙.

This suggests that a total volume exchange of around 200 ml is required. Also, because the infant weighs less than 1.5 kg, it follows that 5 ml-sized blood aliquots should be switched each cycle.

We divide the entire blood volume by the volume per cycle to determine the number of cycles necessary to exchange the complete blood volume. 𝑖.𝑒.

The process is carried out extremely slowly, taking 4-5 minutes every cycle, as was already said. Taking this instance into consideration, the total time for the exchange transfusion on the newborn will be equal to the time utilized each cycle times the overall number of cycles. 𝑖.𝑒. 40 𝑐𝑦𝑐𝑙𝑒𝑠 ×4𝑚𝑖𝑛𝑠 𝑐𝑦𝑐𝑙𝑒\s=160𝑚𝑖𝑛𝑠 = 2 ℎ𝑟𝑠 40 𝑚𝑖𝑛.