TITLE: EFFECTS OF THE HEMOPUMP (HP) ON ORGAN BLOOD FLOW DISTRIBUTION DURING CARDIOGENIC SHOCK IN DOGS

AUTHORS: P.F. Wouters, M.D., T. Möllhoff, M.D., U. Mees, M.D., H. Van Aken, M.D., W. Flameng, M.D.
AFFILIATION: Depts. of Anesth. and Surg., Katholic Univ. of Leuven, Leuven, Belgium

The HP is a new miniature left ventricular assist device (LVAD) currently under clinical investigation.[1] The catheter-mounted pump can be introduced quickly via peripheral vascular access and provides non-pulsatile blood flow up to as much as 3.5 liter per minute.[2] The adequacy of non-pulsatile flow devices to mechanically support organ perfusion has not been thoroughly studied yet. We have investigated the effects of the HP on regional blood flow distribution in dogs with experimentally induced cardiogenic shock.

Twelve dogs were anesthetized with nembutal (30 mg / kg) and fentanyl (50 µg / kg), followed by isoflurane 0.5 vol % and supplemental doses of fentanyl. The lungs were mechanically ventilated to maintain normoxia and normocapnia throughout the experiment. Tracer microspheres (TM) were injected in the left ventricle through a pigtail catheter for measurement of regional blood flow distribution. After baseline TM injections, the LAD coronary artery was occluded with a copper coil. Reperfusion was allowed 4 hrs later by removal of the coil and confirmed by angiography. In group 1 (n=6) HP mechanical support was started after 1.5 hrs, and maintained until 16 hrs following LAD occlusion after which the device was removed. Group 2 did not receive hemodynamic support (control, n=6). TM injections were repeated 1.5 , 16 and 17 hrs following LAD occlusion. Data were analyzed using ANOVA with repeated measures, followed by Student's t-test.

Results: In group 2, all dogs except one, died within 8 hrs following LAD occlusion. In contrast, all animals receiving HP support survived for 16 hrs and in this group, 5 dogs could succesfully be weaned from the device. As shown in Table 1, renal and cerebral blood flow did not change from baseline throughout the experiment in group 1. Intestinal and bronchial arterial blood flow decreased during HP support, while hepatic arterial blood flow increased when compared to baseline. Bronchial arterial flow remained lower after removal of the HP. Since no animals in group 2 survived for 16 hrs, blood flow data were only obtained during baseline and 1.5 hrs following LAD occlusion. However, these data did not differ from group 1.

Conclusion: Mechanical left ventricular support with the HP improves survival from cardiogenic shock in dogs. In addition, blood flow to the brain, kidney and liver remains preserved. Intestinal and bronchial arterial blood flow, however, are not supported to a similar extent by the HP.

References
1. Ann Thorac Surg, 1989, 733-755
2. Trans Am Soc Artif Intern Organs Transactions, 1988, 450-454

Table 1: Regional Blood flow distribution during Left Ventricular Assist with the Hemopump

	Baseline	1.5 hr LAD occlusion	16 hrs LAD occlusion (HP)	post - HP
Brain	50 ± 8	36 ± 4	42 ± 14	45 ± 19
Hepatic Artery	6 ± 3	16 ± 6	46 ± 8*	33 ± 13
Intestines	107 ± 31	82 ± 23	78 ± 8*	55 ± 27
Bronchial Artery	94 ± 10	74 ± 24	17 ± 4*	20 ± 12*
Kidney	335 ± 28	374 ± 21	372 ± 56	191 ± 88

mean ± SEM ; * = p < 0.05 vs Baseline ; Blood flow is expressed in ml / min / 100 gr ; HP = hemopump left ventricular assist for 14.5 hrs

A445

TITLE: EVALUATION OF A BREATHING CIRCUIT ALARM SYSTEM BASED ON NEURAL NETWORKS

AUTHORS: J.A. Orr, Ph.D., D.R. Westenskow, Ph.D.

AFFILIATION: Dept. of Anesthesiology, Univ. of Utah, Salt Lake City, Utah 84132

Introduction: We have developed a breathing circuit alarm system capable of providing specific alarm messages such as "expiratory hose disconnect" and "endotracheal tube cuff leak". The alarm system software is based on neural networks (mathematical models of interconnected neurons). The neural network learns to recognize alarm events by the relationships between monitored signals it has seen in previous examples.

Methods: A sensor array at the mouth provided the CO_2, flow and pressure signals from which 30 features were extracted. These breath-to-breath features are input to the neural network. The output from the neural network was the alarm message. The neural networks was trained by creating an alarm condition and telling the network which alarm corresponds to the features resulting from the created event. The training process was repeated until the system automatically identified specific alarms based on the features extracted from the sensor signals.

The alarm system was tested in animals. Thirteen the alarm conditions were created 57 times in five mongrel dogs (20-25 kg) at various controlled ventilation settings and during spontaneous respiration. The features and alarms from every breath were stored in a computer so that the session could be replayed at a later time. Data from four of the dogs was used to train the system. Data from the fifth dog was used for testing. This process was repeated for each animal. After informed consent and IRB approval, the system was tested during 20 general anesthesia cases in the operating room. An observer watched for and recorded all breathing circuit critical events.

Results: A total of 746 events were created in animals. The results are shown in the table below. "General Alarms" refer to less specific alarms such as "breathing circuit obstruction" which are reported by separate neural networks. General alarms provide more robust alarms during times when specific alarm determination is impossible (i.e. at start of use).

During 43.6 hours of clinical testing, 57 events were observed. Of these events observed, 94.7% were correctly reported by the neural network. There were 74 alarms given for which no breathing circuit event could be identified. This gives a rate of 1.7 false positive alarms per hour.

Conclusion: Neural networks provide a powerful tool to automatically integrate and interpret monitored signals and to provide alarm messages that call attention to a specific problem. In the future we plan to expand the neural network alarms system to analyze longer term trends in order to further improve system accuracy and to increase the number of alarm messages.

	Controlled Ventilation	Spontaneous Breathing
General Alarms	99.7 %	96.2 %
Specific Alarms	95.0 %	86.9 %