

## Original Article

# *Innovations in Intra-Aortic Balloon Pump Management: Computer Modem Technology*

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### ABSTRACT

The computer modem technology being developed by Datascope Corporation for the purpose of off-site intra-aortic balloon pump (IABP) monitoring was clinically evaluated in 30 patients requiring IABP support. The Datascope System 95 model IABP with built-in modem was used on all patients. Remote communications via a personal computer with modem were conducted under both routine and emergency settings. The Datascope PC IABP software was evaluated for its user compatibility, efficiency, diagnostic capability and overall usefulness as a clinical tool. During the eight month evaluation period, 87 remote communications were conducted for both routine and emergency IABP evaluation checks. Adjustments were recommended on 22 occasions relevant to balloon timing, trigger mode selection and augmentation volume settings. Eight communications were initiated in emergency settings due to a variety of patient conditions. Emergency intervention was successful in diagnosing and resolving critical situations including atrial arrhythmias, pacemaker timing, low cardiac output syndrome, loss of trigger source, catheter malpositioning and poor augmentation. The diagnostic capabilities and efficient means of data collection by the computer software provide the clinician with a valuable tool for routine IABP clinical monitoring, as well as emergency problem resolution.

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## INTRODUCTION

The first successful clinical application of the intra-aortic balloon pump (IABP) was reported in 1968 by Kantrowitz, et al, in a patient suffering from cardiogenic shock (1). In these early years, the only insertion method available for the intra-aortic balloon (IAB) catheter required surgical intervention. Insertion was considered to be both complicated and time consuming, and as such resulted in the IABP being used as a measure of last resort.

In 1979, the therapy was dramatically enhanced with the development of the percutaneous IAB (2). Further design breakthroughs, such as the development of the first pre-folded IAB in 1985, significantly improved the time and technique required for insertion, and allowed for further expansion of IABP therapy (3). Today, this treatment modality is extensively used in a wide range of clinical settings in which left ventricular failure occurs, regardless of the etiology (Table 1) (1,4). This report is a pilot study of a recently developed computer modem software package entitled PC IABP<sup>a</sup>. PC IABP is a program intended for use in the clinical setting which allows the clinician, from a remote location, to evaluate patient conditions, monitor the status of the IABP, and to troubleshoot the IABP.

### IABP PRINCIPLES AND THEORY: A REVIEW

The IAB catheter is most commonly inserted into the femoral artery and positioned in the descending aorta just distal to the left subclavian (Figure 1). It is connected to an IABP console and is timed to inflate and deflate in synchronization with the mechanical cardiac cycle. At the onset of diastole, inflation occurs resulting in proximal and distal displacement of blood volume in the aorta. When inflated, the IAB catheter is approximately 80 to 90% occlusive of the aorta (2). This displacement of blood volume creates elevated arterial pressures by which coronary artery and systemic perfusion is increased. Deflation occurs just prior to the onset of systole thereby creating reduction in the end diastolic pressure. This allows ejection of the left ventricular contents against a significantly reduced afterload.

The combined effects of IABP therapy — increased oxygen supply, afterload reduction and improved systemic perfusion — afford the myocardium the time to heal and recover function, and provide circulatory support in order to achieve hemodynamic stability (5-9).

## MATERIALS AND METHODS

Thirty adult patients, ages 42-76 years, who required intra-aortic balloon support were randomly selected for this study. A Datascope 9.5 French (Fr.) Percor Dual-Lumen Intra-Aortic Balloon Catheter<sup>a</sup> with the recommended 0.030 inch J guide wire, vessel and sheath dilators, and the 6 inch long 10 Fr. sheath were used on all patients. A Datascope System 95 Intra-Aortic Balloon Pump console, factory equipped standard with 2400 baud internal modem, was used on all patients throughout the study.

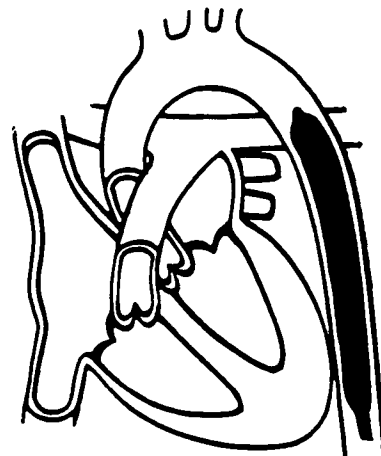
**Table 1**

Indications for IABP therapy.

Unstable Angina  
 Cardiogenic Shock  
 Hypotension Despite Inotropic Therapy  
 Unsuppressible Ventricular Arrhythmias  
 Prophylaxis for Surgery  
 Failed PTCA

**Figure 1**

Correct position of the intra-aortic balloon catheter: resting in the descending aorta just distal to the left subclavian artery.



The Datascope PC IABP computer program was loaded, via a 3.5 inch floppy diskette, into a Grid 1755<sup>b</sup>, 386-based laptop personal computer with 2400 baud internal modem.

A 2 foot long telephone cable with conventional DB-9 male connectors on each end was used to connect the System 95 IABP console to the standard wall telephone outlet.

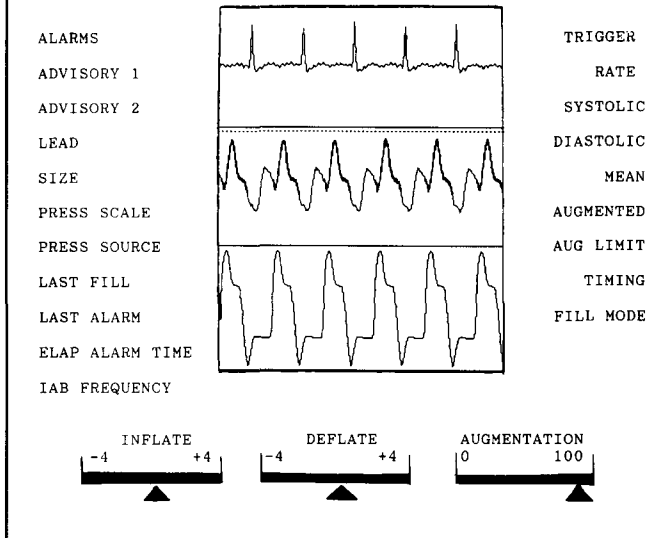
Intra-aortic balloon catheters were inserted under fluoroscopic visualization in the catheterization laboratory (83%) or in the intensive care unit (17%) by cardiologists experienced in the femoral artery Seldinger Technique. A femoral arterial puncture was performed and a 0.030 inch J guide wire was inserted through the needle. Dilation of the subcutaneous tissue and femoral artery was performed using a 5 Fr. to 9 Fr. tapered vessel dilator. A 6 inch long 10 Fr. arterial sheath was placed in the femoral artery over the guide wire previously positioned in the descending aorta. The 9.5 Percor dual lumen intra-aortic balloon catheter<sup>a</sup> was then introduced over the guide wire and through the sheath, and positioned in the descending thoracic aorta just below the origin of the subclavian artery. The System 95 IABP console was connected to the IAB catheter via the 6 foot extension tubing

a Datascope Corporation, Montvale, NJ 07645

b Tandy Corporation, Fort Worth, TX 76102

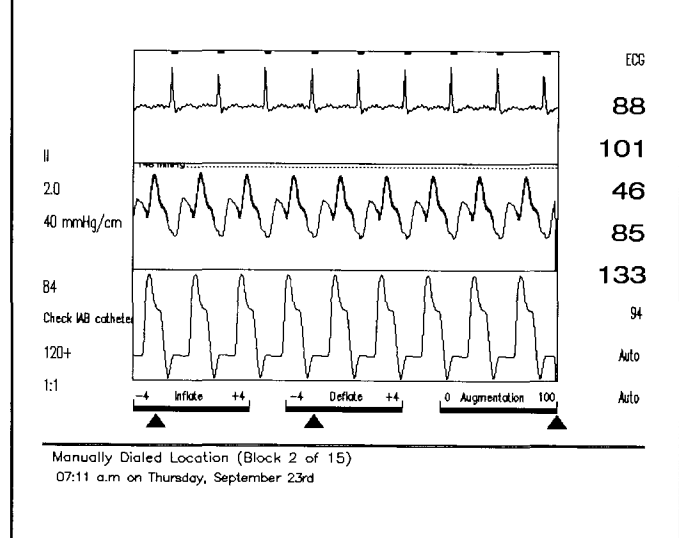
**Figure 2**

The visual display of the data location and tracings one receives on the computer screen while in communication with an intra-aortic balloon pump.



**Figure 3**

The complete data information displayed on the user's computer screen while using the PC IABP software.



provided. The central IAB lumen was aspirated and connected to a primed pressure tubing and transducer in the conventional manner. In this way, aortic root pressure monitoring was ascertained on the IABP console monitor. Along with this maneuver, a continuous patient electrocardiogram was established on the IABP console also in the conventional manner. System 95 IABP console set-up and initiation of counterpulsation was, in all cases, conducted by a trained intra-aortic balloon pump operator.

Each patient received a bolus dose of 5000 IU heparin at the time of balloon insertion and was then given a continuous heparin infusion titrated to maintain a partial thromboplastin time of two times control.

Upon arrival into the intensive care unit, a 12 foot telephone cable with conventional DB-9 male connectors was connected into the modem telephone port on the System 95 IABP console, and then into the nearest wall telephone jack. This connection provided the ability for the off-site computer to communicate with the IABP console via telephone line transmission.

Routine clinical evaluations via remote communications were conducted twice daily, once at 7 a.m. and again at 7 p.m., by a trained IABP operator. Intensive care unit nursing personnel familiar with IABP patient care were utilized on each patient, consistent with the nursing protocol at our institution.

The PC IABP software package provides the user with immediate and accurate information regarding the monitoring of the IABP patient. Figure 2 demonstrates the visual display one receives while using the PC IABP software. The intent of the software is to provide the user with complete ECG, arterial blood pressure and intra-aortic balloon tracings in 10 second updated intervals. These on-line tracings are received in the identical

format as they are displayed on the IABP console itself. In addition, the software provides the user with all the necessary information required to completely assess the IABP console settings. These are displayed down the left and right margins of the screen and are continuously updated with each 10 second interval (Figure 2). In addition, the patient's hemodynamic parameters are continuously displayed along the top half of the right margin in precisely the same way they appear on the IABP console. Along the bottom margin of the computer screen, the precise settings of the inflation, deflation and augmentation volume controls are displayed. Figure 3 is an example of the complete data information displayed on the user's computer screen while using the PC IABP software. It is in this way that the user is then able to assess the IABP console's settings, present and past alarms, as well as the patient's hemodynamic status.

One initiates a communication session by first entering the DIAL IABP portion of the program, and then manually enters the telephone number of the desired IABP console location. One is also able to permanently store this telephone number along with an associated name and location into the PHONE BOOK portion of the program. Once logged into the PHONE BOOK, the user can easily retrieve this location and its associated phone number from the PHONE BOOK, and may command the modem to automatically dial this location. Presently, up to 99 separate locations may be stored in the phone book for automatic dialing. Once communication is initiated with an IABP console, incoming data is displayed on the computer screen, as shown in Figure 3, and continuously updated approximately every 10 seconds. The user is able to store entire communication sessions on the computer's hard disk. These sessions can, at any time, be replayed, transferred to a floppy diskette, or printed out as hard

copies for the purpose of permanent documentation for future reference.

The PC IABP program also provides the ability for the user to enter notations onto the screen while on-line with an IABP console. This function, referred to as the MEMO function, when selected discontinues monitoring of the balloon catheter trace and allows this section of the computer screen to be used for notation. This is a very useful feature for clarifying difficult or obscure findings with regard to diagnosis and analysis. Also, specific documentation can be made for medical record keeping purposes.

Throughout the trial period, 87 remote communications were initiated. Routine maintenance checks were made twice daily, one in the a.m. and one in the p.m. Trained intra-aortic balloon pump personnel were continuously available on a 24 hour on-call basis for any difficulties encountered by nursing personnel managing the patient, as is the protocol for our institution. In addition to the off-site evaluations being performed, the routine daily bedside IABP evaluations were also performed by the IABP technicians. The purpose of the off-site computer maintenance evaluations was to add to the frequency and convenience of IABP monitoring and patient care. Routine IABP off-site maintenance checks via the computer technology on average required 1 to 2 minutes per session to complete. These sessions include those which did not require any adjustments to the IABP. Emergency intervention sessions requiring diagnosis and problem resolution on average required 9 minutes (range 6 to 12 minutes) to complete.

## RESULTS

During the eight month evaluation period, 87 remote communications, via the PC IABP computer program, were initiated for routine IABP evaluation check. Adjustments were recommended on 22 occasions. Twelve adjustments were made with regard to IABP timing settings: seven inflation setting changes, three deflation setting changes, and two occasions when both inflation and deflation settings were adjusted. Trigger mode selection was changed on four occasions: three occasions in which a pressure trigger mode was deemed preferable over ECG trigger mode, and one occasion when atrio-ventricular pacing trigger mode was recommended. ECG lead selection changes were made on three occasions due to problems of artifact or low voltage reception. IABP augmentation volume settings were adjusted on two occasions for the purpose of optimal diastolic augmentation. The arterial blood pressure scale was changed on one occasion in order to improve arterial blood pressure trace analysis.

Emergency intervention was necessary on eight occasions. An emergency was defined as an urgent situation in which the IABP either ceased pumping or was experiencing a frequent alarm problem in which IABP operation was subject to interruption and could not be resolved by the nursing personnel managing the patient. On three occasions a loss of trigger source occurred

due to a blood gas technician drawing a sample of blood and momentarily eliminating the arterial input trace necessary for arterial blood pressure triggering. On two occasions a rapid gas loss occurred due to the IAB extension tubing becoming disconnected from the IABP console. On three occasions poor augmentation concerns from nursing personnel were diagnosed as a catheter malposition problem. In all of these cases the IAB catheter was positioned too low in the descending aorta. After radiographic confirmation was received, the IAB catheter was advanced and augmentation subsequently improved.

## DISCUSSION

Clearly, the IABP is the most extensively used of all cardiac assist treatment modalities, as it has proven effective, safe and easy to initiate for use in the treatment of patients in cardiogenic shock (10). With the ever-increasing application of the intra-aortic balloon pump in the critically ill patient, the need for efficient management of the patient requiring intra-aortic balloon pump support has become even more necessary. The PC IABP software program offers the clinician a valuable tool for the management of the IABP patient never before available in the clinical setting. The PC IABP software allows the on-call IABP technician—or any clinician—to be fully on-line with an IABP console in a matter of seconds with full hemodynamic status information, as well as complete information as to the IABP control settings and alarms. This results in the elimination of the technician response time which may often prove critical in emergency situations. The efficient and accurate information one is able to obtain while on-line with the IABP provides one with the ability to routinely evaluate the patient status as well as to quickly troubleshoot problems which may arise. With the advent of the PC IABP software, problem resolution time is greatly reduced, and routine monitoring of the IABP patient may be conducted within minutes from nearly any remote location. The PC IABP software offers an advancement in IABP patient care which is sure to be state-of-the-art for future intra-aortic balloon pump management.

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