

Original Article

Single Hospital Experience with Emergency Cardiopulmonary Bypass Using the Portable CPS® (Bard) System

Barbara L. Wittenmyer, RN, CCT; B.J. Pomerants, MD; Steven B. Duff, MD, FACS; William D. Watson, MD, FACS; James M. Blackford, MD, FACS

Riverside Methodist Hospitals, Columbus, Ohio

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ABSTRACT

One hundred four patients were placed emergently on the Bard CPS® portable femoro-femoral bypass system over a 4 year period. Thirty-two patients (31%) were discharged from the hospital. Seventy-six of these patients (73%) required emergency bypass following cardiac arrest, and twenty-eight patients (26%) were in cardiogenic shock or respiratory failure. In the arrest group, no one survived an unwitnessed arrest and those with cardiopulmonary resuscitation times less than 30 minutes had a better survival rate. The highest survival rate was in those patients who did not arrest prior to bypass. Fifty-two percent of these patients were released.

The 74 patients receiving interventional therapy on bypass had a higher survival rate than those unable to be treated. Of the thirty patients receiving no intervention, only three (10%) were eventually discharged. For the 19 patients receiving treatment only in the cardiovascular laboratory, the discharge rate was 26%. Of the 55 patients taken to the operating room for surgical correction, 24 (44%) were discharged from the hospital.

No patients placed on bypass at an outlying hospital or treated using CPS® within 72 hours of a previous open heart procedure survived.

Please address all correspondence to:

Barbara Wittenmyer, CCT
Department of Perfusion
Riverside Methodist Hospitals
3535 Olentangy River Rd.
Columbus, Ohio 43214

INTRODUCTION

The search for methods to support the acutely ill patient led to the development of easily inserted transportable cardiopulmonary bypass systems. As the availability of these systems has expanded, questions have arisen regarding the appropriate application of this technology. By examining early experiences with the Bard CPS[®] a portable femoro-femoral cardiopulmonary bypass system, patterns may emerge which contribute to improved success.

Riverside Methodist Hospital, a large private institution in Columbus, Ohio, utilized the system in 104 patients from December 1987 through December 1992. Analysis of these patients revealed 31% were discharged following the placement on the CPS[®] system. There were no survivals of unwitnessed arrests. Interventional measures improved survival with surgical intervention producing the best outcome.

MATERIALS AND METHODS

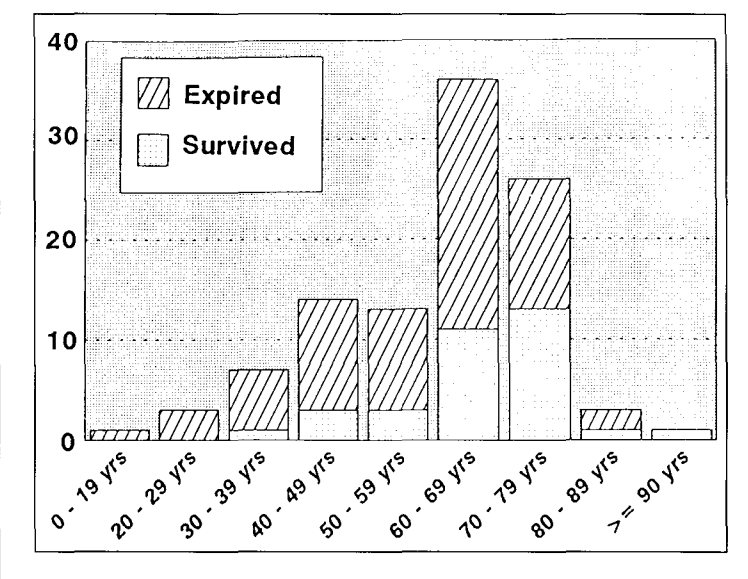
All patients in this study were managed on the Bard CPS[®] emergency cardiopulmonary bypass system. Patients were initially cannulated femorally, using either the Bard femoral cannula system (early in the study) or Biomedicus^b femoral cannulae (from January of 1990). A surgeon placed the cannulae in 33% of cases and a cardiologist in 67%. Fifty percent of insertions took place in the cardiovascular laboratory, 15% in the critical care units, 11% in the emergency department, and 24% in other areas, including three at an outlying hospital. For all insertions at Riverside, certified perfusionists set up and conducted CPS[®] under the supervision of a cardiologist or thoracic surgeon.

At the initiation of our CPS[®] program, little was available regarding the appropriate clinical uses of the emergency bypass system. Therefore, the Riverside Technology Utilization Committee established a list of limitations for use. Absolute contraindications to the insertion of CPS[®] included aortic insufficiency and known brain death. The presence of irreversible organ damage and diagnosed terminal illness also generally precluded placement. Additional factors considered were unwitnessed arrest, length of arrest, recent stroke, gastrointestinal hemorrhage, presence of abdominal aortic aneurysm, and trauma.

Data collected involved the retrospective analysis of 104 consecutive patients placed on CPS[®] from December 1987 through December 1992. The standard data collection form showed demographics, diagnosis, procedure(s), CPS[®] initiation and conduct and patient outcome. Patients undergoing elective insertion for PTCA and placement solely for long term support were excluded from the study. Only those postoperative sequelae directly related to the bypass period were recorded.

When analyzing outcome, patients were divided into three

Figure 1: Mortality by age group. 'Survived' includes all patients discharged. 'Expired' includes all patients who failed to wean and all late deaths



categories. "Failure to wean" included all patients who expired within 12 hours of the termination of bypass. All patients who survived greater than 12 hours but expired without leaving the hospital fell into the second group, "late death," regardless of time elapsed following bypass. All patients listed in the "survival" group were successfully discharged from the hospital. Statistical analysis was performed using general linear models regression.

RESULTS

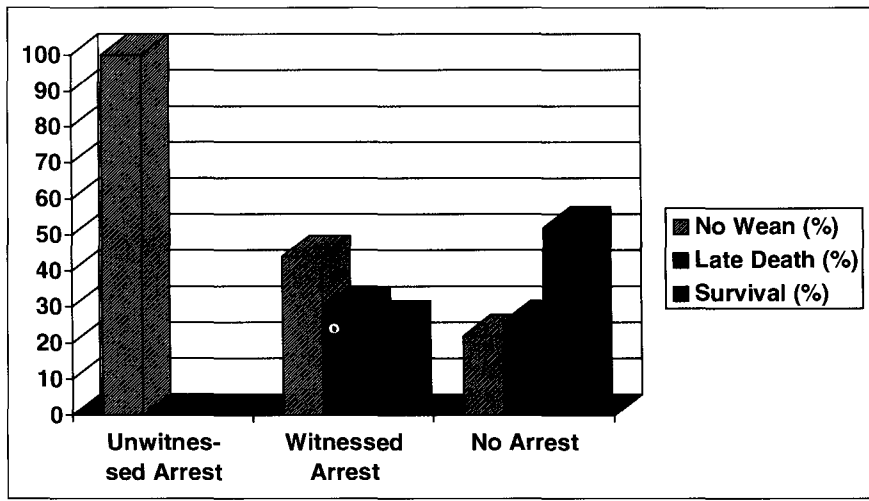
Emergency cardiopulmonary bypass was performed on 68 male and 36 female patients. They ranged from 18 to 91 years of age, with an average age of 60 years. The overall survival rate was 31% (32 patients). Patients 70 to 79 years of age had the highest survival rate at 50% (Figure 1). Of the ten patients under the age of 40, only one survived. The one patient over the age of 90 years did survive. Although there was no significant difference in average age by sex (the average age for females was 62 years, 59 years for males), the survival rate for females was higher (44%) than for males (23%) ($p < .05$).

Indications for initiation of bypass fell into three categories: cardiopulmonary arrest, cardiogenic shock, and pulmonary insufficiency. The patient's status prior to CPS[®] placement did affect outcome (Figure 2). There were 76 patients requiring cardiopulmonary resuscitation (CPR) for cardiopulmonary arrest. Six arrests (8%) were unwitnessed by medical personnel.

a Bard Cardiopulmonary Division, Tewksbury, MA

b Medtronic Biomedicus, Eden Prairie, MN

Figure 2: Patient survival versus pre-bypass condition



None of these patients was weaned from bypass. The average CPR time in this group was 50 minutes.

Sixty-six patients had witnessed arrests. The average CPR time in this group was 26 minutes, with a minimum of 3 minutes and a maximum of 140 minutes. Twenty-nine patients were unable to be weaned from bypass, 20 expired more than 12 hours after being weaned, and 17 patients (24%) were discharged from the hospital. All but one of the patients in the survival group received CPR for thirty minutes or less. An additional four patients had arrests requiring CPR, but were eliminated from this analysis due to incomplete records. None of these patients survived.

Patients placed on CPS® for cardiogenic shock or pulmonary insufficiency without cardiac arrest had a significantly greater survival rate than those who arrested prior to placement ($p < .02$). Twenty-seven patients fell into this category. Fourteen of these patients (52%) were discharged from the hospital while only six were unable to be weaned from bypass.

Survival rate increased with the ability to intervene while on CPS® (Figure 3). Thirty patients received no cardiologic or surgical intervention. Twenty-one of these patients could not be weaned from bypass, six expired later in the hospital stay, and only three patients (10%) were eventually discharged from the hospital.

Eighteen patients received percutaneous transluminal coronary angioplasty (PTCA) and/or thrombolytic therapy as the only treatment modality and one had an aortic valvuloplasty. Six of these patients were unable to be weaned from

CPS®, eight expired in the hospital, and five (26%) were discharged.

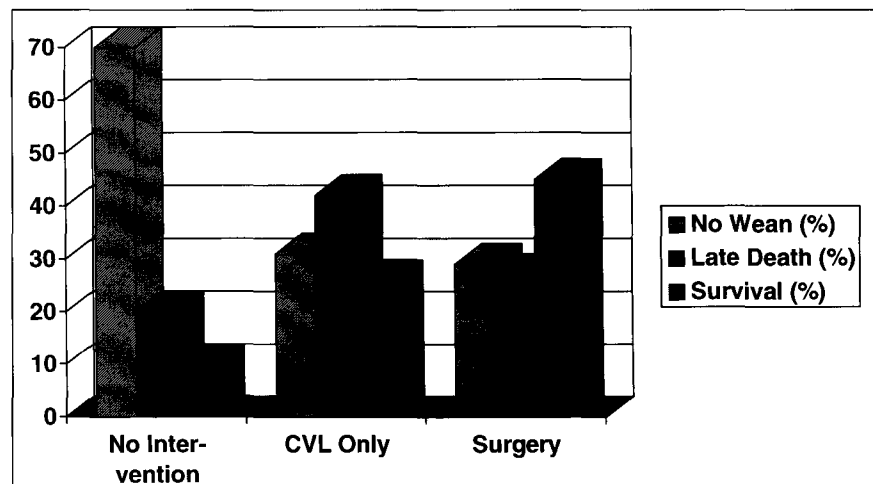
Fifty-five patients underwent a wide variety of surgical procedures. The surgical procedures performed included coronary artery bypass grafting, valve replacement, pulmonary embolectomy, ventricular septal defect repair, and repair of cardiac perforation and rupture. Sixteen patients were unable to be weaned, 15 expired later and 24 (44%) were discharged from the hospital. Twelve patients were converted to standard cardiopulmonary bypass for surgical intervention while 43 patients were left on the CPS® system with minimal adaptation for their procedures. For those patients requiring total bypass for open cardiac procedures, the venous cannula was retracted into the inferior vena cava. A superior vena caval cannula was placed and Y'd into the venous line as described by Jenkins and Holt (1). Those left on CPS had a 46% survival rate, while those converted to standard bypass had a 33% survival rate, not a statistically significant difference.

DISCUSSION

A multi-institutional report from the National Cardiopulmonary Support Registry, published in 1992, reported a 21.4% greater than 30-day survival rate in 187 patients undergoing emergency cardiopulmonary bypass. Of these patients, 74.9% received diagnostic or therapeutic interventions while on bypass (2).

From December of 1987 through December of 1992, 104

Figure 3: Patient survival versus treatment. CVL refers to those patients receiving PTCA, stents, and/or thrombolytics while on CPS.



patients were placed on the Bard CPS® system at Riverside Methodist Hospital. Thirty-two of these patients (31%) were discharged from the hospital, including 44% of all females. An additional four patients lived greater than 30 days following their bypass procedures, but expired without leaving the hospital. These patients were not included in the "survival" group.

The majority of patients in this study were placed on emergency cardiopulmonary bypass (ECPB) during CPR for cardiopulmonary arrest. None of the six patients with unwitnessed arrests was able to be weaned from bypass. This supports the prevailing opinion of most authors that the application of emergency bypass is usually contraindicated in unwitnessed arrest (2-3) except in the case of hypothermic arrest (4-7).

Of the 66 witnessed cardiac arrest patients, 18 (25%) were eventually discharged. Thirteen patients received CPR for greater than 30 minutes. Only one patient in this group survived following 40 minutes of CPR. Two other patients receiving CPR for greater than 30 minutes were successfully weaned from bypass, but both expired due to severe hypoxic neurologic injuries. These findings tend to support other studies which indicate that CPR times in excess of 30 minutes greatly reduce the chance of survival (2, 8-10). However, if the patient remains neurologically intact and the potential for anatomic correction exists, placement on ECPB should be considered.

The highest survival rate occurred in patients not requiring CPR at the time of insertion. Fifty-two percent (14) of these patients were discharged from the hospital. This may indicate that earlier initiation of emergency bypass may reduce the incidence of cardiac arrest and its subsequent morbidity and mortality. The primary cause of death in 41% of the patients receiving CPR was neurological death and an additional 14% remained unresponsive following bypass. Only one patient not requiring CPR had major neurologic impairment. This further supports the contention that early introduction of bypass may improve outcome.

Patients receiving no interventional therapy had only a 10% survival rate. Six of these patients were placed on ECPB within 72 hours following open heart surgery with no long term survivals. Also included in this group were three hypothermic patients requiring ECPB for rewarming. All three patients were victims of trauma, one head injury of unknown cause, and two cold water drownings following automobile accidents. Only one of these three was successfully weaned and none survived.

Seventy-four patients placed on ECPB (71%) underwent therapeutic intervention. This group had a 39% survival rate. Patients treated only in the catheterization lab by PTCA and/or thrombolytic therapy or valvuloplasty had a 26% survival rate.

The 55 patients undergoing surgical intervention had a survival rate of 44%. Twelve of these patients were converted to standard bypass for their surgical procedures. The remainder were left on CPS®. Thus, the variety of procedures performed using the two bypass systems were similar. While the survival rate for those left on CPS at 46% was higher than those converted to standard bypass (33%), this difference was not statis-

tically significant due to the relatively small converted population.

Examining the survival by age distribution produced some interesting results. The best survival rate occurred in patients between 70 and 79 years of age (50%). The poorest survival rate occurred in the ten patients under the age of 40 years (10%). Examining those patients revealed that most had relative contraindications to CPS® insertion. Five patients received CPR for greater than 30 minutes, three had unwitnessed arrests, and three were placed on ECPB following multiple traumas. Only one patient had coronary artery bypass grafts while seven received no intervention. In most of these cases, the patients would not have been considered candidates were they older. Older patients, as those in the 70 to 79 year old group, were not placed on ECPB unless they met all other criteria for optimal outcomes.

Two additional groups of patients merit special mention due to their poor outcomes. Three insertions were performed at an outlying institution by local staff, then transported for intervention. All three patients expired. None of these patients had any demonstrable neurologic function following CPS® insertion. Patients placed on ECPB within 72 hours following open heart surgery also had poor outcomes. Of the six patients in this category, three were unable to be weaned from ECPB and none was discharged. Two patients placed on ECPB for cardiopulmonary arrests following open heart procedures did survive. Both were at least 10 days post-surgery. One of these two patients required a pulmonary embolectomy while the other experienced a severe bradyarrhythmia requiring pacemaker implantation while on ECPB.

In conclusion, emergency portable cardiopulmonary bypass is a viable method for dealing with acute cardiac or respiratory failure. In this study the survival rates improved when CPS® was placed prior to arrest. In patients who did arrest, CPR times of less than 30 minutes improved survival and no one survived an unwitnessed arrest. Intervention improved survival, with the best results occurring in patients receiving surgical correction. Improved success may depend upon earlier intervention and better screening of candidates prior to insertion. This requires better education of essential personnel and rapid activation of the team as well as reassessment of the bypass system as improvements become available.

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