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Use of Arterial Catheters in the Management of Acute Aortic Dissection

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Abstract

Purpose—The aim of this study was to investigate the relationship between the use of invasive arterial blood pressure (IBP) monitoring and reaching established aggressive medical management goals in acute aortic dissection.

Methods—Data were collected through a retrospective chart review of patients diagnosed with acute aortic syndromes of the thoracic cavity who required transport to tertiary care over a 28-month period. The 2010 American Heart Association medical management goals of thoracic aortic disease were used as hemodynamic end points.

Results—A total of 208 patients were included, with 113 (54%) diagnosed at least in part with acute Stanford Type A aortic dissections and the remaining 95 (46%) having isolated Stanford Type B dissections. Emergency departments made up 158 (76%) of transfer departments; 129 (62%) patients had IBP catheters placed. The highest mean systolic blood pressures (SBPs) recorded were 165 mm Hg in the IBP group versus 151 mm Hg when noninvasive blood pressure (NIBP) cuffs were used ($P < .01$). The mean decrease in SBP during transport was 51 mm Hg in the IBP group versus 34 mm Hg in the NIBP group ($P < .001$). The difference between the last reported NIBP and the first IBP was noted as 19 mm Hg higher. The IBP group met the SBP goal more frequently than the NIBP group ($P < .05$) when the SBP was noted as greater than 140 mm Hg during transport. Bedside time increased only 6 minutes with IBP placement ($P < .007$).

Conclusion—Patients with IBP catheters were noted to be more aggressively managed with antihypertensive medications, met hemodynamic goals more frequently, and had only 6 minutes longer bedside times. These findings support the placement of IBP catheters by emergency departments and critical care transport (CCT) teams in patients with acute aortic syndromes requiring interfacility transport to definitive care.

Introduction

Acute aortic dissections (AoDs) are life-threatening emergencies associated with high mortality. There are 6,000 to 10,000 new cases of recognized AoDs every year in the United States; approximately 40% of patients die immediately with rupture of the aorta, 1% die every hour after the start of the dissection, and between 5% and 20% die perioperatively.¹ Advances in surgical treatment methods over the last decade have decreased patient mortality; however, ensuring that these patients reach appropriate definitive care remains an ongoing challenge. Even after a prompt diagnosis in the emergency department, patients may still require transport to larger tertiary centers for surgical intervention or endovascular repair.

Aggressive medical management through anti-impulse and blood pressure control strategies has long been used since first proposed by Wheat et al² in contention with the landmark Deakey et al³ study 4 years earlier recommending surgical intervention in all acute AoDs. Aggressive medical management of heart rate and blood pressure has been shown to help decrease extension of the AoD and maximize the patient's likelihood of reaching the operating room. In 2010, the American Heart Association (AHA), in collaboration with multiple other nationally recognized organizations, developed practice guidelines to assist clinicians in the diagnosis, management, and prevention of acute AoD of the thoracic aorta. These guidelines establish a stepwise approach to meeting specific hemodynamic goals of a heart rate (HR) less than 60 beats per minute (bpm), pain control, and systolic blood pressure (SBP) less than 120 mm Hg¹ (Fig. 1).

The relationship between methods of blood pressure monitoring (invasive arterial blood pressure [IBP] catheter vs. non-invasive blood pressure [NIBP] cuff) and how quickly AoD patients meet the established SBP goal has not previously been observed. Currently, the majority of blood pressure measurements in AoD patients are obtained through NIBP measurements, which have been shown to underestimate the true SBP, overestimate diastolic blood pressure, and provide only intermittent data.⁴⁻⁷ Given these limitations, early institution of IBP monitoring may be a preferable alternative to NIBP measurements in the acute AoD population. Several studies have recognized that arterial catheters provide the most accurate method of continuous monitoring of blood pressure. One review also noted that nonphysician providers with proper training and education could safely place IBP catheters.⁸ However, no studies currently exist addressing IBP placement within the context of medical transport, specifically comparing time as the key factor in reaching specific hemodynamic goals and controlling hypertension. Therefore, the aim of this study was to investigate the relationship between the use of IBP monitoring and reaching established aggressive medical management goals in acute AoD for patients undergoing medical transport.

Methods

Design

This was a retrospective cohort study of all nontraumatic thoracic AoDs transported by a critical care transport (CCT) team from a 1,300-bed tertiary care center in the Midwest

United States between January 2010 and April 2012. The study was part of a quality improvement program targeted toward the development of best practices regarding CCT in this population. Patients were divided into 1 of 2 cohorts based on the method of blood pressure monitoring during transport (IBP vs. NIBP). The CCT team is unique in that it involves a crew configuration not traditionally used in the field. The team includes a critical care nurse and a paramedic led by an acute care nurse practitioner (ACNP) and uses ground, rotor, and fixed wing modes of transport that are staffed 24 hours a day, 7 days a week. The ACNP has prescriptive authority and hospital privileges that allow for individualized care to be provided instead of a universal standard protocol for every patient. Each ACNP decided independently whether or not to place an IBP catheter for hemodynamic monitoring and what specific medications to administer to reach AHA goals based on the preferred methods of the receiving hospital. The specific extremity chosen for IBP placement was a critical decision that incorporated knowledge of patient anatomy, location of dissection, and assessment of perfusion to that artery.

Study Sample

All patients transferred by the CCT team by air (rotor or fixed wing) to the 1,300-bed tertiary care center with a confirmed diagnosis of acute AoD were eligible for inclusion. AoD was defined as any aortic dissection with a component above the diaphragm as well as intramural hematomas confirmed by either a board-certified radiologist (via computed tomographic imaging, magnetic resonance imaging, or ultrasound) or direct visualization in the cardiac catheterization laboratory. Because electronic medical record documentation was only available for patients transported by air, those transported by ground were excluded from this analysis. Patients whose SBP never exceeded 140 mm Hg were also excluded from the HR and SBP analysis because IBP catheters may not have an effect on SBP management in patients who are not hypertensive. The AHA defines stage 1 hypertensive as having an SBP from 140 to 159 mm Hg, and, therefore, 140 mm Hg was chosen as the cutoff. There were no cases identified in which patients refused IBP placement during transport.

Data Sources

Eligible patients were identified using the CCT program's quality monitoring database. Clinical coordinators from the CCT program enter patient information into this database at the end of each transport using a standardized electronic form including, but not limited to, patient identifiers, referring diagnosis, and mode of transport. This database was designed by a single trained analyst who is responsible for database quality monitoring. Patient identifiers were then used to access the electronic medical records (EMRs), including the tertiary care hospital's Epic System (Verona, Wisconsin), and the transport team's Golden Hour (San Diego, California) charting program. These EMRs are used in air medical transport nationally as reliable programs for both interhospital documentation and billing. A single data collection nurse with expertise in data management and familiar with the CCT database identified and collected all data points using a standardized data collection form.

Outcome Measures

The independent predictor variables were the presence of either an IBP or NIBP cuff. The primary outcome variables were cuff to A-line variation in blood pressure readings, change

in SBP, change in HR and bedside times, and whether the patient reached the AHA BP and HR goals. Cuff to A-line was defined as the difference between the last reported cuff and the first reported arterial catheter pressure. Change in SBP was defined as the change in SBP from the highest to lowest reported pressures documented at any point during the transport. Similarly, change in HR was defined as the change in HR from the highest to the lowest reported during the transport. Bedside time began from when the CCT team arrived at the referring hospital bedside and ended when the helicopter or airplane wheels lifted off the ground. Times were recorded into the EMRs and entered into the CCT database.

AHA goals defined goal HRs and SBPs not as ranges but as specific end points. For the purpose of this study and determining the "real-world" success of reaching these goals, achieving a goal HR was defined as 2 consecutive HR measurements less than 70 bpm at least 5 minutes apart. Similarly, achieving a goal SBP was defined as 2 consecutive SBP measurements less than 130 mm Hg at least 5 minutes apart. Motivation for these altered hemodynamic parameters and consecutive measurements are 2-fold: once a clinician comes close to a goal measurement, less aggressive medication titration and administration may take place so as to not overshoot the goal, and reaching a hemodynamic goal only momentarily will not have the same beneficial pathophysiological effects as when these goals are maintained.

Statistical Analysis

The research plan was approved by the institutional review boards of the CCT team's hospital and associated university. Basic patient demographics, degree of change in blood pressure, last cuff and first arterial measurements and associated times, types and amounts of medications administered, length of hospital stay, and disposition of the patient were assessed using independent samples *t*-tests. Categorical data were analyzed using the chi-square test. All analyses were performed using SPSS Statistics (IBM, Armonk, NY).⁹

Results

From January 2010 until April 2012, a total of 318 patients were entered into the CCT database with a diagnosis of AoD. A cohort of 208 patients was identified in the review who met the inclusion criteria and were transported by either rotor or fixed wing modes of transport. In the 110 patients not meeting the inclusion criteria, 32 had isolated abdominal dissections below the diaphragm, and 78 were transported by ground without EMR records available for review. There were no significant differences noted in patient sex or age between the NIBP and IBP groups (Table 1). Overall, 62% (129/208) of the patients had an IBP catheter placed during interfacility transport versus 38% (79/208) with only an NIBP cuff. An IBP arterial catheter was placed in the right radial (45% [58/129]), left radial (37% [48/129]), right brachial (4.7% [6/129]), left brachial (3.9% [5/129]), right femoral (7.8% [10/129]), and left femoral (1.6% [2/129]) arteries before arrival at the receiving facility.

In those patients in whom an arterial catheter was placed, a mean increase of 19 mm Hg was noted between the last documented cuff SBP and the first documented arterial catheter SBP. This group also received significantly more antihypertensive medications (77% compared with 63% for NIBP). The mean time interval between recorded cuff to A-line pressures was

8 minutes. Ninety-one patients had an SBP noted to be greater than 140 mm Hg during the transport, with 58% of those with an IBP catheter noted to reach the SBP goal versus only 40% of the NIBP group ($P < .05$). SBP levels were also noted to decrease an additional 17mm Hg when an IBP was present or 54 mm Hg in the IBP group versus 34 mmHg in the NIBP group ($P < .001$). The mean bedside time was noted as 25 minutes in the NIBP group versus 31 minutes in those patients in whom the CCT team placed an IBP ($P < .007$). A detailed review of the full results can be found in Table 2.

Discussion

This study shows an association between IBP catheter use during air medical transport and achieving hemodynamic blood pressure goals more frequently in hypertensive patients with acute AoD. It also demonstrated more aggressive use of antihypertensive medications and only negligible increases in bedside times. Although IBP catheters have been cited as the gold standard for blood pressure monitoring, they have not routinely been placed in many emergency departments because of time constraints, staff education, and available equipment. Only 9% of the patients in this study had an IBP catheter placed by the referring facility before transfer, 53% had an IBP placed by the CCT team, and the remaining 38% were monitored by NIBP cuff alone. Because appropriate specialized interventions can at times be a great distance away, optimization of medical management before arrival is essential. The majority of patients in this study (76%) sought care in their local emergency departments and were determined to require emergent cardiovascular services not available at the referring facility.

These results are not only statistically significant but also clinically useful in the management of acute AoDs according to the AHA medical management guidelines. These results show that medical management using inexact NIBP measurements could appear as though the goal SBP was achieved, whereas in reality the patient remains hypertensive. Literature supports the use of IBP as the gold standard of hemodynamic monitoring and acknowledges that SBP levels are typically higher when compared with NIBP measurements.^{4-6,8} This study further supports those findings in that SBPs were, on average, 19 mm Hg higher between the last NIBP and first IBP measurements in the same patient. This is the first study to cite this phenomenon in this specific patient population and exemplifies another variable in the difficulty of optimizing medical management of acute AoDs before reaching appropriate tertiary care.

Interestingly, HR improved more significantly in the NIBP group although the majority of IBP patients did receive some type of beta blocker medication. This raises the question of how clinicians choose to alter their medication choices when presented with 2 continuous sets of hemodynamic variables, HR and SBP. The AHA management guidelines explicitly state to meet the HR goal of less than 60 bpm before management of SBP less than 120 mm Hg. Clinicians in this study using NIBP measurements may have more aggressively managed HR because they were not distracted by continuous blood pressure measurements. This may suggest a need for caution to avoid any possible distraction that IBP monitoring may present.

One argument against the placement of IBP catheters in patients with time-sensitive emergencies is the potential delay in reaching definitive care because of the procedure itself. In our study, the mean bedside time was increased by only 6 minutes in patients in whom an IBP catheter was placed before departure. Six additional minutes of bedside time at the referring facility may be reasonable if improved hemodynamic control lessens the likelihood of extension or rupture of the dissection before arrival at the referring facility. Statistically, the IBP directly uncovers unseen hypertensive conditions and allows the SBP to be treated more aggressively, which directly decreases the length of time it takes to optimize care to AHA hemodynamic goals. If a patient has to wait for IBP placement until after arrival at the tertiary care center, it creates an unnecessary delay in meeting the recommended goals.

Certain limitations should be mentioned. This was a retrospective chart review, and, as such, it was limited only to patient records that were able to be linked across all documentation sources. Patients without complete data may have experienced different outcomes. Additionally, this was a quality improvement project with results that are specific to our program. This retrospective chart review included patients managed by 17 different ACNPs of all different experience levels. Some ACNPs were more proficient and skilled at the placement of arterial catheters. ACNPs were all educated in the most recent AHA guidelines; however, the specific management strategies varied. Physicians at the accepting facility ultimately favored an attempt at IBP placement during transport regardless of current hemodynamic status, thus eliminating a selection bias of invasive monitoring only in the most critically ill patients. The study took place over a 28-month period, and, as such, the ACNPs' procedure and management skills continued to improve as they evolved in their medical practices. These evolutionary changes do not detract but rather enhance the clinical management results identified. The study has a degree of inherent bias present from the nature of the retrospective form of analysis. The time intervals also differed between the documentation of vital signs on every trip, which were noted as longer as the trip length extended, although overall trends were captured. This study did not control for IBP location, catheter brand, or anesthesia used in placement.

Conclusion

Patients with IBP monitors were noted to have significantly higher SBP measurements, were more aggressively managed, and had only slightly longer bedside times. These findings support the placement of IBP catheters by emergency departments and CCT teams in patients with acute AoD requiring interfacility transport to definitive care. As health care systems continue to consolidate and emergent transfer to specialized centers becomes more commonplace, research needs to continue to focus on the integration of best practices before reaching tertiary care.

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Figure 1.
Initial Medical Management Aortic Wall Stress¹

Table 1

Patient Demographics

	NIBP (n = 80)	Arterial Line (n = 128)	P Value
Sex (female)	39	52	.25
Age, median	64 (47–80)	66 (50–81)	.39
Dissection, type A	37	76	.02

NIBP = noninvasive blood pressure cuff.

Table 2**Results**

	NIBP (n = 80)	Arterial Line (n = 128)	P Value
Surgical intervention (%)	36 (45)	67 (52)	.30
LOS (days) ^a	15.78	14.48	.43
Bedside time (minutes)	25 (12–38)	31 (12–50)	.007
Total trip time (minutes)	52 (32–72)	66 (32–107)	.001
SBP, highest ^b	151 (126–176)	166 (130–202)	.001
SBP, change during trip ^b	34 (13–55)	51 (20–82)	.0001
HR, highest ^b	88 (68–108)	85 (65–105)	.31
HR, change during trip ^b	20 (5–35)	16 (4–28)	.035
Met SBP goal (%)	50 (63)	90 (70)	.36
Met SBP goal ^c (%)	19 (40)	53 (58)	.05
Met HR goal (%)	41 (51)	68 (53)	.74
Antihypertensives used (%)	50 (63)	98 (77)	.04
Beta blockers used (%)	55 (69)	102 (85)	.097

HR = heart rate; LOS = length of stay; NIBP = noninvasive blood pressure cuff; SBP = systolic blood pressure.

Bedside time is defined as the time from arrival at bedside until wheels lift off. Total trip time is the time from the arrival at bedside until patient handoff at the receiving hospital.

^a Surgical intervention population.

^b Mean.

^c Excluded patients with SBP never > 140 mm Hg (NIBP [n = 48] and IBP [n = 92]).