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Hemodynamic Management of Patients with Ejection Fraction < 50% Undergoing Pulmonary Vein Ablation

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Abstract

There is no consensus regarding optimal methodology for blood pressure monitoring in patients with a depressed ejection fraction undergoing catheter ablation for atrial fibrillation. Our goals were to determine if hemodynamic management differences exist during radiofrequency ablation for atrial fibrillation in patients with and without an ejection fraction< 50%, and whether management was influenced by the utilization of invasive arterial blood pressure monitoring. This single-center trial retrospectively compared blood pressure management during catheterablation of atrial fibrillationin all patients with an ejection fraction< 50% over a 2-year span (n=44), and compared to an age-matched cohort with preserved ejection fraction ablated over the same span in time (n=44). Blood pressure was not significantly managed differently between the groups, and did not appear to be influenced by the use of invasive arterial blood pressure monitoring. Hemodynamic management is similar across the spectrum of ejection fraction, regardless of invasive arterial blood pressure monitoring, which challenges the need for invasive arterial blood pressure monitoring during catheter ablation of atrial fibrillationin left ventricular systolic dysfunction.

Introduction

It has been over 15 years since the early description of catheter ablation (CA) outcomes for atrial fibrillation (AF) in patients with left ventricular systolic dysfunction (LVSD) [1]. Subsequently, the results of multiple studies [2-7], and most recently the Catheter Ablation Versus Medical Rate Control in Atrial Fibrillation and Systolic Dysfunction (CAMERA-MRI) [8], Catheter Ablation for Atrial Fibrillation with Heart Failure (CASTLE-AF) [9] and Effect of Catheter Ablation vs Antiarrhythmic Drug Therapy on Mortality, Stroke, Bleeding, and Cardiac Arrest Among Patients with Atrial Fibrillation (CABANA)[10] have suggested efficacy of catheter ablation (CA)for achieving normal sinus rhythm in patients with AF and LVSD. None of these studies, however, described the hemodynamic management during the CA process. Also, current an esthesia recommendations and Heart Rhythm Society guidelines are vagueregarding the subject of optimal methodology for blood pressure monitoring in LVSD during CA for AF[11-13].We sought to determine if significant blood pressure management differences exist between patients with and without significant LVSD undergoing CA of AF, and whether management was influenced by the use of invasive arterial blood pressure monitoring (IABP).

Key Words

Ablation, Atrial fibrillation, Left ventricular systolic dysfunction, Tolerance

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Materials and Methods

All patients with an EF< 50% undergoing CA for AF over a 2-year span were included in the retrospective analysis. An age-matched cohort with preserved EF (> 50%) also having CA for AF during the same timeframe was included for comparison [Table 1].The study was approved by the University of Kentucky institutional review board. Pre-procedure, there was no discontinuation of guideline-directed or advanced medical therapies for heart failure (including continuous milrinone). Cessation of anti-arrhythmic drug therapy 5 days prior occurred at the discretion of the attending electrophysiologist.

All CA procedures were performed after informed consent was obtained, and under general anesthesia. The choice of inhaled anesthetic (desflurane, isoflurane, sevoflurane) and paralytic agent (rocuronium, succinylcholine, etomidate) was determined by the attending anesthesiologist. Otherwise, propofol(150 mg) or dexmedetomidine (1 mcg/kg), lidocaine (50 mg) and fentanyl (100 mcg) single boluses were also dosed at induction. Venous vascular access was obtained at all sites with ultrasound guidance. All patients were also monitored with an indwelling intracardiac echocardiography (ICE) catheter throughout the CA. The method of blood pressure monitoring, invasive arterial blood pressure (IABP) via a radial line versus a non-invasive cuff, was also determined by anesthesia services. Vasopressor (VP) agents were given for a 20% drop in mean arterial pressure (MAP) from baseline, or to maintain MAP > 60 mmHg. VP dosing was charted at time of occurrence. Choice of VP titration, continuous drip (phenylephrine 0.1-0.25 mcg/min or norepinephrine 2-4 mcg/min) and/or bolus (ephedrine 5 mg, phenylephrine 100-200 mcg, and/or vasopressin 1

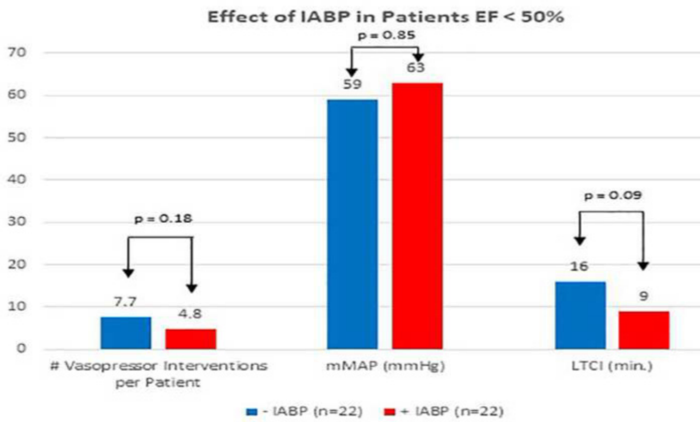

Figure 1: Effect of IABP in patients EF < 50%

unit) was determined by the attending physician/nurse anesthetist as well. Intra-operative up-titration of milrinoneoccurred at the discretion of the attending electrophysiologist. Vital signs were charted at least every 5 minutes. All patients received a Foley catheter to monitor urinary output.

Radiofrequency CA was accomplished with a 3.5 mm irrigated tip catheter. This consisted of a wide circumferential isolation of all pulmonary veins (left veins first followed by the right), then posterior wall isolation for patients with persistent AF only, and ablation of resultant or inducible atrial tachyarrhythmias in all patients. An intra-cardiac echocardiography catheter provided continuous monitoring capabilities to address the presence of a pericardial effusion when needed. An isoproterenol drip at 10 mcg/min was used during the post-ablation induction process. Single doses of protamine 100 mg and furosemide 60 mg were given intravenously once the study was completed. All access sheaths were then removed. Hemostasis was obtained via direct manual compression for an internal jugular venous sheath, and a purse-string stitch with manual compression at both groins. The endo-tracheal tube was removed at study completion in the procedure room. Chest radiography(CXR) was ordered post-procedure by advanced practice providers to rule out pneumothorax, and for other clinical reasons on an individual basis.

Patients were recovered on a telemetry unit with planned discharge home the next day. Near term follow-up consisted of a 1-week post procedure phone call and 1-month office visit.

Data Analysis

Specified data endpoints included procedure duration, percent continuous IABP and VP utilization, number of VP interventions per patient, time of VP intervention, time to first VP intervention, minimum MAP (mMAP), average procedural urinary output > 100 ml/hour, length of stay, 30-day re-hospitalization, and longest time of continuous intervention (LTCI). A VP intervention was an instance of VP bolus in time or initiation/titration up or down of a VP drip. LTCI was defined as the longest time of VP bolus and/or drip titration before a 5 minute charting gap not requiring an intervention was reached. The effect of IABP monitoring presence on number of interventions, mMAP, and LTCI in the EF < 50% groups was also studied.

Statistical Analysis

Statistical analysis included student's t-test for comparison of unpaired means, and Fisher's exact for comparison of continuous categorical variables. A p-value < 0.05 was considered statistically significant.

Results

All patients had successful completion of the intended ablation. There were no incidences of pericardial effusion or complications at the vascular access sites. Additionally, ablation of induced or converted rhythms (atrial flutter, atrial tachycardia, and typical atrio-ventricular nodal reentry tachycardia) occurred and were most common in the EF 7lt; 40% group; 70% (16/23), but not significantly more than the EF 40-49%; 33% (7/21) or EF > 50%; 34% (15/44) groups. [Table 2] displays the results for the specified study endpoints. Other than IABP utilization there were no significant differences among the study groups. The presence of IABP monitoring [Figure 1] also did not significantly influence the number of VP interventions, mMAP, or LTCI. Use of a vasopressor drip [Table 3] was not different amongst all groups. Its use significantly lessened the number of VP interventions only within the EF 40-49% group, and had no significant impact otherwise on mMAP or LTCI.

[Figure 2] shows the number of VP interventions with respect to time during the ablation procedure. There appeared 3 distinct periods of increased VP intervention, 0-95 minutes, 96-125 minutes, and 126-200 minutes. The most interventions in a single patient within a 5-minute charting period was a single instance of 4, followed by 2 instances of 3. These all occurred in patients with EF > 50% and no IABP monitoring. Average hourly urinary output was > 100 ml/hour during the procedure in 95% (42/44) of EF > 50%, 81% (17/21) of EF 40-49%, and 87%

Table 1: Baseline Characteristics at Procedure Initiation

Group	n	% male	Age (y)	% Diuretic	% Anti-HTN	% DM or PN	% NSR	MAP (mmHg)	Mean HR (bpm)
EF ≥ 50%	44	66 (29/44)	62	25 (11/44)	80 (35/44)	25 (11/44)	59 (26/44)	99 +/- 18	82 +/- 25
EF < 50%	44	80 (35/44)	60	64 (28/44)	95 (42/44)	32 (14/44)	45 (20/44)	94 +/- 17	83 +/- 18
EF 40-49%	21	62 (13/21)	63†	33 (7/21)	90 (19/21)	43 (9/21)	38 (8/21)	99 +/- 17	86 +/- 18
EF < 40%	23	96 (22/23)	57†	91 (21/23)	100 (23/23)	22 (5/23)	52 (12/23)	90 +/- 16	80 +/- 19
EF 31-39%	6	100 (6/6)	56	100 (6/6)	100 (6/6)	0 (0/6)	33 (2/6)	85 +/- 12	81 +/- 25
EF 21-30%	10	90 (9/10)	48	80 (8/10)	100 (10/10)	40 (4/10)	70 (7/10)	87 +/- 13	76 +/- 20
EF ≤ 20%	7	100 (7/7)	63	100 (7/7)	100 (7/7)	14 (1/7)	42 (3/7)	100 +/- 16	84 +/- 11

DM = diabetes mellitus, HR = mean heart rate, HTN = hypertension, MAP = mean arterial pressure, NSR = normal sinus rhythm, PN = peripheral neuropathy

Table 2: Specified Procedure Outcomes

Group	Procedure Time (min.)	% IABP	% Needing VP	% VP Drip Use	Total # Interventions (Int. per Patient)	Time to First Int. (min.)	mMAP (mmHg)	Mean LTCI (min.)
EF ≥ 50%	151	2 (1/44)* + †	80 (35/44)	29 (10/35)	221 (5)	34	58	12
EF < 50%	156	50 (22/44)*	95 (42/44)	50 (21/42)	276 (6)	32	61	13
EF 40-49%	157	24 (5/21)+	95 (20/21)	70 (14/20)	165 (8)	27	61	17
EF <40%	156	74 (17/23)†	96(22/23)	32 (7/22)	111 (5)	35	61	9
EF 31-39%	133	67 (4/6)	83 (5/6)	20 (1/5)	41 (7)	31	59	9
EF 21-30%	167	70 (7/10)	100 (10/10)	40 (4/10)	51 (5)	35	61	7
EF ≤ 20%	159	86 (6/7)	100 (7/7)	29 (2/7)	19 (3)	38	62	13

EF = ejection fraction, IABP = invasive arterial blood pressure, Int. = Intervention, LTCI = longest time of continuous intervention, mMAP = minimal mean arterial pressure, VP = vasopressor

(20/23) of EF < 40% groups (p=NS). All patients were extubated and had complete discontinuation of VP drips before leaving the procedure room. All patients except one in the EF 40-49%group (96%) were recovered and monitored on a telemetry unit. The single exception had transient complete heart block post ablation that resolved with cessation of beta blockade by the next morning after intensive care unit observation. Three EF < 40% patients (13%)required post-op intervention for respiratory status before discharge the following day. One was for subjective shortness of breath, mild vascular congestion on CXR, and decreased oxygen saturation.

Management consisted of brief bi-level positive airway pressure and a single intravenous dose of furosemide. Two patients had shortness of breath, mild vascular congestion without edema on CXR, and received a single dose of intravenous furosemide.

Length of stay was 1.3± 1.8 days in the EF > 50% group, 1.1± 0.5 days in the EF 40-49%group and 1 day in the EF < 40% group (p=NS). A single patient with EF > 50% (2%) had a pre-existing pacemaker system issue that required management and a 13-day stay, and one EF 40-49% patient (5%) had nausea and vomiting due to suboxone withdrawal prompting a 3-day stay. Three patients each in the EF >50% (7%) and < 50% (7%) groups were re-hospitalized within 30 days. One in each group was for infection, one also in the EF 40-49% group for astroke event presenting as confusion/dizziness (positive head CT scan), and one in the EF < 40% group for hypokalemia. One patient in the EF < 40% group had abdominal discomfort with shortness of breath and was discharged from the emergency room following a brisk diuresis 4 days after their procedure.

Discussion

In addition to efficacy, understanding safety is critical for wider acceptance of CA for AF in LVSD by the general electrophysiology community. To date, there is no study of CA for AF describing the hemodynamic management and optimal methodology for blood pressure monitoring, particularly in those with significant LVSD. This study showed the hemodynamic management of a radiofrequency CA procedure in a cohort of patents with EF < 50%under general anesthesia to be similar to that of a preserved EF population. There was no significant difference between groups for the specified hemodynamic endpoints. IABP monitoring did not significantly affect the need for VP interventions within EF 40-49% and EF <40% groups and when they were compared to an EF > 50% group. Taken together our data are also suggestive of the safety of non-invasive blood pressure monitoring for VP titration in the LVSD population. This is particularly relevant to the overall safety of the process given that vascular issues are the most frequently reported complication of CA for AF, albeit occurring in only approximately 2% of cases[14]. The rate of major complication from radial artery access is fortunately significantly less [15]. A resultant compartment syndrome, however, can be very devastating. The femoral arterymay be also utilized for IABP monitoring as well for CA of AF, and was not used in this study. Femoral access can contribute to the incidence of pseudoaneurysm and AV fistula[16]. These complications can be eliminated or minimized with use of non-invasive blood pressure cuffs.

Three distinct periods of increased blood pressure intervention were identified during the CA process in this study, each likely with a different physiologic cause. The first period began shortly after anesthesia induction and was likely due to a combination of negative inotropy, attenuated sympathetic reflex, pre-load reduction, and decreased vascular resistance [19-20]. The second occurred when programmed stimulation, linear lines for posterior wall isolation, or rhythm conversion to atrial flutter were most common, likely contributing to transient increased VP needs following pulmonary vein isolation [21-22]. VP interventions were more prominently seen in the EF 40-49% group in this timeframe. Patients with heart failure mid-range EF (HFmrEF) have been shown to have a large prevalence, upwards of 76%, of diastolic dysfunction based on echo cardiographic findings [23]. Our mid-range EF group was not categorized HFmrEF

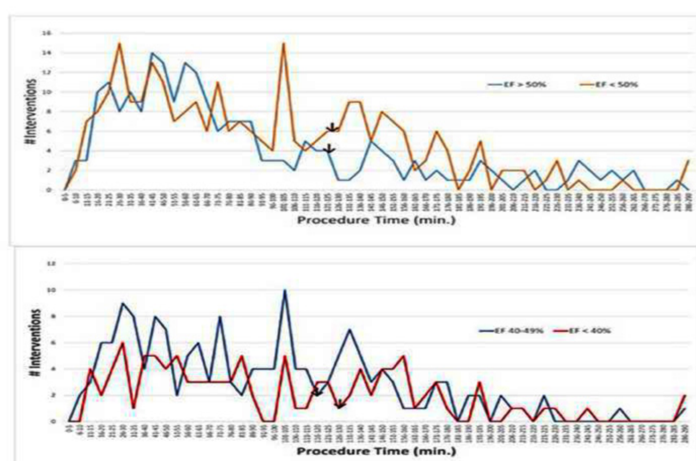

Figure 2: Specified Procedure Outcomes.

EF = ejection fraction, IABP = invasive arterial blood pressure, Int. = Intervention, LTCI = longest time of continuous intervention, mMAP = minimal mean arterial pressure, VP = vasopressor simply because we did not seek to establish the European Society of Cardiology diagnostic criterion in this group [24]. There does not appear to be a consensus at this point whether this EF range represents a new category of heart failure [25]. However, the authors separately analyzed this group to see if there were any hemodynamic differences detectable in our process. It seems reasonable to assume that our EF 40-49% group may have had some incidence of diastolic dysfunction to explain the hemodynamic reaction during this timeframe. The third period of escalation correlated with initiation of isoproterenol. The vasodilatory effects of its beta-2 receptor actions may outweigh the beta-1 receptor agonist increase in heart rate and contractility, thus causing a drop in blood pressure [26]. Each of the groups showed similar responses during the active isoproterenol infusion and washout phase. Regardless, the physiologic effects and the corrective actions in all 3 time periods, were similarly experienced and efficiently managed in all groups regardless of IABP use.

Overcorrection of hypotension from VP interventions did not appear to be an issue as only one instance of intravenous beta blockade was dosed for this reason in a patient receiving VP boluses in the 88 patient study population. Otherwise, VP drips were titrated down without issue to achieve the desired MAP.

Limitations

This study represents the non-randomized experience at a single facility with modest sample size, using general anesthesia, and radiofrequency energy. There were multiple anesthesia practitioners, who were not dedicated cardiac specialists. As such, this likely provided more variability in management choices, including the use of IABP monitoring. Our results are also not necessarily applicable to an alternate anesthesia strategy. Regardless, the patients were safely attended within this construct resulting in similar management whether or not IABP monitoring occurred.

Time to first VP intervention, number of interventions, mMAP, average hourly urinary output > 100 ml/hr, and LTCI were chosen as measures of hemodynamic tolerance by the investigators, and to our knowledge have not been described before for this purpose. Their validity may be questioned. These data endpoints, however, seemed a reasonable means to describe blood pressure management within our process.

Table 3: Effect of Vasopressor Drip Presence on Intervention Management

Group	# Interventions (Int. per Patient)		p value	Mean LTCI (min.)		p value	mMAP (mmHg)		p value
	- Drip	+ Drip		- Drip	+ Drip		- Drip	+ Drip	
EF > 50% (n=35)	133 (5.3)	88 (8.8)	0.26	11	16	0.20	58	59	0.65
EF < 50% (n=42)	175 (8.3)	101 (4.8)	0.13	12	13	0.64	60	61	0.50
EF 40-49% (n=20)	96 (16)	69 (4.9)	0.03	20	16	0.25	58	61	0.47
EF < 40% (n=22)	79 (15)	32 (4.6)	0.78	10	7	0.26	60	62	0.60

CA = catheter ablation, ICD = implantable cardioverter defibrillator, Q = every

There were no incidences of tamponade and access site bleeding in this study. This was likely due to operator experience, ultrasound guidance and use of ICE for venous and transseptal access. As such it is unclear from our results whether IABP would have been superior to a non-invasive cuff for navigating such adverse events in those not as experienced or utilizing ICE and ultrasound for access.

Conclusions

Hemodynamic management of CA for AF appears similarly experienced in patients across the spectrum of EF. Blood pressure interventions were handled in a timely fashion with and without IABP monitoring. The need for increased VP intervention in the 3 groups in 3 distinct time periods was universal, and not influenced by the presence of IABP monitoring. Based on our findings, vascular complications can be further minimized with use of non-invasive cuffs for blood pressure monitoring without sacrificing safety in the LVSD population in our process. CA for AF, even in patients with Class IV chronic systolic heart failure on ambulatory inotropic therapy, appears to be safe in the hands of experienced practitioners. Further study will be required to further address safety and efficacy in this group.

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