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Original Article

Intraoperative Predictors of Long-term Outcomes After Radiofrequency Endometrial Ablation

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ABSTRACT **Study Objective:** To identify intraoperative predictors of radiofrequency ablation (RFA) failure after adjusting for clinical risk factors.

Design: A cohort study (Canadian Task Force II-2).

Setting: An academic institution in the Upper Midwest.

Patients: Data were retrospectively collected from medical records of women who underwent RFA and who had a postprocedure gynecologic assessment between April 1998 and December 2011.

Interventions: RFA.

Measurements and Main Results: The primary outcome was RFA failure, which was defined as hysterectomy, repeat ablation, synechiolysis, or treatment with gonadotropin-releasing hormone analogue for postablation pain or bleeding. Cox proportional hazards regression was used to test the predictability of intraoperative variables on RFA failure with adjustment for baseline predictors. We created an RFA index to capture the procedure duration divided by the uterine surface area. One thousand one hundred seventy-eight women were eligible. The median age at ablation was 44 years (interquartile range, 40–48 years), and the median parity was 2 (interquartile range, 2–3). Dysmenorrhea and prior tubal ligation were reported in 37.1% and 37.2% of women, respectively. After adjustment for baseline characteristics, intraoperative predictors of failure were uterine sounding length >10.5 cm (adjusted hazard ratio [HR] = 2.58; 95% confidence interval [CI], 1.31–5.05), uterine cavity length >6 cm (adjusted HR = 2.06; 95% CI, 1.30–3.27), uterine width >4.5 cm (adjusted HR = 2.06; 95% CI, 1.29–3.28), surface area >25 cm^2 (adjusted HR = 2.02; 95% CI, 1.26–3.23), procedure time <93 seconds (adjusted HR = 2.61; 95% CI, 1.25–5.47), and RFA index <3.6 (adjusted HR = 3.14; 95% CI, 1.70–5.77).

Conclusion: Intraoperative parameters are predictive of long-term adverse outcomes of RFA independent of patient clinical characteristics. Uterine length, procedure duration, and RFA index are associated with unfavorable outcomes and thus could be used to optimize postprocedure patient counseling. Journal of Minimally Invasive Gynecology (2016) 23, 582–589 © 2016 AAGL. All rights reserved.

Keywords: Endometrial ablation; Hysterectomy; NovaSure; Uterine bleeding

Abnormal uterine bleeding (AUB) is a common gynecologic condition that affects up to 14% of women during the reproductive years and adversely impairs their health and quality of life [1]. Heavy menstrual bleeding (HMB) is the most common pattern of AUB and is associated with high rates of operative intervention and gross financial burden [2,3]. Medical treatment with oral contraceptive pills or levonorgestrel intrauterine devices is generally the first line of therapy [3]. Failure of medical treatment warrants further intervention, which was limited to hysterectomy until the late 1980s when endometrial ablation (EA) evolved as an alternative.

EA describes a range of minimally invasive techniques to treat HMB using a hysteroscopic approach [4]. Although

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first-generation devices were initially used in 1967 [5], guidelines that define proper practice of EA were established about 3 decades later [6]. The emergence of simpler second-generation EA techniques encouraged further popularity of the procedure, which became the most common treatment of HMB in 2008 [7]. This contributed to the substantial decline in hysterectomy rates by over 40% between 2002 and 2010 [8]. EA is associated with less morbidity and almost half the overall costs compared with hysterectomy [9,10].

However, EA failure, which is as high as 26% within 8 years of the procedure in some reports, may double the burden on the patient by requiring another intervention [7]. Therefore, many studies have identified potential predictors of EA outcomes in hopes of minimizing failure rates through proper patient selection [11–13]. These studies primarily addressed baseline patients' demographic and clinical attributes as indicators of failure. With the exception of uterine sounding length, associations between characteristics of the uterus as well as the procedure itself with outcomes have not been previously reported in the literature [14]. In this study, our objective was to evaluate whether intraoperative-related parameters impacted long-term radiofrequency ablation (RFA) outcomes after adjustment for known baseline predictors.

Material and Methods

An EA registry was created in 2004 at Mayo Clinic, Rochester, MN, that included data of patients who underwent EA from 1998 and is maintained to the current date; relevant data including patients' demographics, preoperative evaluation, EA intraprocedural parameters, surgical complications, and outcomes are entered by a trained registered nurse or postdoctoral research fellow. We have previously published data using this database [11,15–18]. For this study, we included women who underwent EA for HMB at Mayo Clinic, Rochester, MN, between April 1998 and December 2011 and followed up through March 2015. We ascertained the cohort by searching for the *International Classification of Diseases, Ninth Revision, Clinical Modification* code 68.23 for EA through electronic medical records [19]. All women were evaluated by clinical examination; the Papanicolaou test and endometrial sampling were up-to-date at the time of the procedure. Pelvic ultrasound and/or office hysteroscopy were used if an intracavitary lesion was suspected. From this cohort, all women who underwent RFA (NovaSure; Hologic, Inc, Bedford, MA) and had postprocedure gynecologic records were considered eligible. Women were excluded if the procedure was not completed as indicated by the radiofrequency controller, if they received a levonorgestrel-releasing intrauterine system inserted concomitantly or after ablation (for contraception or preoperative dysmenorrhea), or if they had less than 6 months of follow-up.

Data abstracted from the medical records included patients' demographics (age at ablation, parity, and body mass index), preprocedure bleeding and pain patterns, past medical history (coagulopathy, liver diseases, renal diseases, and thyroid replacement therapy), past surgical history (previous gynecologic surgeries including tubal ligation and cesarean sections), sonographic features (endometrial thickness, features suggestive of adenomyosis, uterine leiomyomas, and intracavitary lesions), preprocedure hysteroscopic findings, and hematologic tests within 12 months before surgery (hemoglobin level and serum ferritin). Intraprocedure variables included uterine length as measured by sounding, uterine cavity length measured from the fundus to the endocervix, uterine width as measured by the RFA device, intrauterine surface area (uterine cavity length in cm $\times$ uterine width in cm), duration of the procedure in seconds, and concomitant uterine procedures including preablation sharp or suction curettage. We created an RFA index to address the duration of the procedure in relation to the uterine surface; the RFA index was calculated as the procedure duration divided by the surface area. A lower RFA index indicates that less time was used per surface area of the uterus.

The primary outcome of our study was RFA failure defined as subsequent development of AUB, pelvic pain, or dysmenorrhea that necessitated surgical intervention such as repeat ablation, hysterectomy or synechiolysis, or medical intervention, namely the administration of gonadotropin-releasing hormone. Women were censored at the time of menopause, as shown by amenorrhea and a serum follicle-stimulating hormone level $>$40 mIU/mL or age $>$55 years [20], date of last clinical follow-up, or hysterectomy for non–ablation-related indications. Women who had failure were further subdivided according to the primary cause of intervention to either failure because of postablation pain or because of AUB. Patients with both significant pain and bleeding, as evidenced by subjective severity or necessity for medications, were considered in both subgroups.

This study was approved by the Mayo Clinic Institutional Review Board, and only women who provided research authorization were included.

Statistical Analysis

We used Cox proportional hazard models and Kaplan-Meier curves to assess the association between baseline and intraoperative variables and RFA. The proportional hazards assumption was checked for each of these models by graphically evaluating the Schoenfeld residuals. Baseline variables that had p values $<$.2 in univariable regressions were included as adjustment variables in multivariable models for each intraoperative variable. For continuous variables with no known clinically relevant cut points, we serially tested potential cutoff points in the model in an ascending manner. Each time, the cutoff point was increased by 0.5 cm (for uterine length and width) and 2 units for power. The cutoff point that provided the highest odds ratio