Manual Compared With Electric Vacuum Aspiration for Abortion at Less Than 6 Weeks of Gestation

A Randomized Controlled Trial

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OBJECTIVE: To evaluate whether manual or electric vacuum aspiration results in greater immediate confirmation of completed abortion at less than 6 weeks of gestation.

METHODS: Five hundred pregnant women presenting for surgical abortion with mean gestational sac diameter of less than 12 mm or no visible sac on ultrasonography were randomized to manual or electric vacuum aspiration. Tissue examination was performed by operating physicians, not blinded to group assignment, and by trained medical assistants, blinded to group assignment. Patients with no products of conception on gross inspection underwent repeat aspiration as necessary and serial human chorionic gonadotropin monitoring. All patients were scheduled for follow-up visits. The primary outcome was detection of products of conception in patients with subsequently confirmed completed abortion.

RESULTS: From April 2010 to October 2011, 252 patients were randomized to manual vacuum aspiration and 248 to electric vacuum aspiration. One hundred eighty-two (82%) patients in the manual vacuum aspiration group had products of conception identified and subsequently confirmed completed abortion compared with 164 (76%) patients undergoing electric vacuum patients ($P=0.13$, relative risk $0.83$, 95% confidence interval [CI] $0.64–1.07$). In pregnancies of sac size 3 mm or less, including no visible sac, five of 29 (17%) patients undergoing manual vacuum aspiration had accurate identification of products of conception compared with four of 31 (13%) patients undergoing electric vacuum aspiration ($P=0.64$, relative risk $0.85$, 95% CI $0.44–1.63$). Tissue reports of physicians and medical assistants had 90% concordance. Seventy-nine (16%) patients required human chorionic gonadotropin monitoring to confirm completed abortion. There were seven (1.4%) ongoing pregnancies, including four false-positive products of conception results and, among the latter, one presumed ectopic pregnancy.

CONCLUSION: Our study supports providing abortions to women who request them before 6 weeks of gestation using either manual or electric vacuum aspiration. Early aspiration is highly effective, although human chorionic gonadotropin monitoring may be necessary to confirm complete abortion.


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LEVEL OF EVIDENCE: 1

Women with undesired pregnancies frequently present for surgical termination at less than 6 weeks of gestation; however, many are unable to obtain abortions this early in pregnancy. Although published reports demonstrate that early surgical abortion is safe, approximately one third of facilities that provide abortion in the United States do not offer

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surgical abortion at less than 6 weeks of gestation.\(^4\,5\) In early pregnancy, the amount of tissue obtained is scant and health care providers may have difficulty identifying products of conception, a necessary step in confirming completed abortion.\(^6\)

Two different suction devices, manual vacuum aspirators and electric vacuum aspirators, are used interchangeably in first-trimester surgical abortion and both are safe and effective.\(^4\,7\,8\) The manual vacuum aspirator is more portable, inexpensive, quiet, and does not require electricity. In contrast to the continuous vacuum with the electric device, the manual syringe may need to be emptied to complete the abortion procedure.\(^7\,9\) One published report suggested manual vacuum aspiration may improve the likelihood of products of conception identification through less damage to removed tissue. This retrospective study included only two abortions at less than 6 weeks of gestation performed using electric vacuum aspiration, however.\(^7\)

No studies have specifically compared manual with electric vacuum aspiration for very early abortion or for products of conception detection. Therefore, we conducted a randomized trial to evaluate whether manual or electric vacuum aspiration for abortion at less than 6 weeks of gestation produces uterine aspirates that lead to a higher proportion of immediate confirmation of completed abortion. We also compared rates of completed abortion, ongoing pregnancy, and additional testing to confirm completed abortion.

**MATERIALS AND METHODS**

We conducted a randomized trial from April 2010 to October 2011 comparing two suction devices commonly used in early surgical abortion, manual vacuum aspirators and electric vacuum aspirators. The study was approved by the Sterling institutional review board. All patients aged 18 years or older who presented to Planned Parenthood of New York City requesting surgical termination of pregnancy at less than 6 weeks of gestation by ultrasonography and who did not meet exclusion criteria were invited to participate. We excluded patients with contraindications to outpatient abortion (including medical conditions posing significant health risk and contraindications to intravenous sedation in patients unable to tolerate abortion under local anesthesia), suspected ectopic pregnancy (no intrauterine pregnancy in the setting of complex adnexal mass or unilateral pain or ectopic pregnancy seen on ultrasonography), suspected molar pregnancy, suspected completed spontaneous abortion (no gestational sac and vaginal bleeding), and failed medication abortions.

Participants were randomized to one of two study groups: abortion using manual or electric vacuum aspiration in a one-to-one ratio. A study team member not involved in patient enrollment used a computer-generated randomization sequence using blocks of sizes four and six. Volunteers not associated with patient enrollment placed study group assignments in sealed opaque sequentially numbered envelopes. A research associate not involved in clinical care enrolled patients in the study and affixed the envelopes sequentially to participants’ charts before they entered the operating room. The operating physicians opened the envelopes when the patients entered the operating room. The physicians were all experienced abortion providers. Physicians could select the canula type (rigid or flexible) and size and choose whether to use ultrasonographic guidance during the abortion procedure. Gross tissue inspections in this study were performed twice: by operating physicians, who thus were not blinded to study group assignment, and by trained medical assistants, who were blinded to study group assignment. The operating physician inspected first, rinsing with tap water and then floating the uterine aspirate in water in a glass Pyrex dish placed on a photographic light box. Then the physician left the tissue inspection room and the medical assistant inspected the tissue. Handheld magnifying lenses (5×) were available for use. Tissue inspection results were either positive (both villi and sac seen) or negative (neither villi nor sac seen, only one seen, or uncertain). Identification of a fragment of gestational sac was considered positive identification of a sac, and identification of any amount of villi was considered identification of villi. Equivocal findings were recorded as negative.

Management of abnormal tissue results followed agency protocols. When physicians did not identify both villi and sac in the uterine aspirates, they ordered serial human chorionic gonadotropin (hCG) levels to determine complete abortion; the first hCG level was drawn on the day of the abortion, and the patient was instructed to return for a second hCG level in 48–72 hours. Physicians could choose to perform a postprocedure ultrasonogram and reaspiration when they did not identify complete products of conception after an initial aspiration. Uterine aspirates with negative findings were sent for pathology examination (in accordance with facility protocols, aspirates with complete products of conception were not sent to pathology). All patients were scheduled for routine follow-up visits in 2–3 weeks, which included a low-sensitivity pregnancy test (Pregnacol, level of sensitivity of 1,500–2,000 mIU/mL). Patients with positive tests received, as indicated, physical examinations, ultrasonograms, and serum hCG tests.
Physicians completed forms on the abortion procedure, tissue inspection, and management of any complications. The medical assistants completed separate forms on the results of their tissue inspections. The study coordinator abstracted data about patients' demographic and background information and follow-up visits from the electronic medical record system. The study coordinator contacted all patients who did not return for follow-up more than 2 months after the procedure to request that they return for a follow-up visit to assess their pregnancy status. For patients who failed to return within 30 days after this first phone intervention, the researcher contacted them again to assess pregnancy status over the phone (absence of pregnancy suggested by patients' reports of regular menses or of being seen by an outside clinician who confirmed she was no longer pregnant).

Gestational age was determined by ultrasonography performed by certified ultrasound technicians before study enrollment. We considered gestational sac size less than 12 mm or no visible sac with positive pregnancy test to be less than 6 weeks of gestation. For the first 219 patients enrolled, if a gestational sac was visible on ultrasonogram, gestational age was determined by a single measurement of gestational sac length in the longitudinal plane; sac length less than 12 mm met inclusion criteria. In the 10th month of the study, ultrasonographic protocols were changed at the clinical site; ultrasonographers were required to obtain mean sac diameters to calculate gestational age. Henceforth, for the remaining 279 patients, if a gestational sac was visible and greater than 3 mm, gestational age was determined by the mean sac diameter, calculated as the mean of the sac width (measured in the transverse plane) and sac length and height (measured in the longitudinal plane); mean sac diameter less than 12 mm met inclusion criteria (for sac size 3 mm or less, a single longitudinal measurement was used).

The primary outcome variable was the proportion of true-positive detection of products of conception in the uterine aspirate. True-positive meant that products of conception were identified in patients with subsequently confirmed completed abortion. Because there is no single test for completed abortion, we created a composite variable called "completed abortion" (Fig. 1). Completed abortion was confirmed when a patient had one of the following indicators:

1. Negative low-sensitivity pregnancy test on routine follow-up examination
2. Fifty percent or greater decline in postoperative serum hCG levels in patients with no or incomplete products of conception identified on immediate postabortion tissue inspection
3. Positive low-sensitivity pregnancy test on routine follow-up examination, but:
   a. Ultrasonography showing absence of the gestational sac (for patients with a gestational sac on preoperative ultrasonography); or
   b. Fifty percent or greater decline in postoperative hCG levels (for patients with no gestational sac on preoperative ultrasonography but products of conception identified on postabortion tissue inspection)
4. Absence of ongoing pregnancy on subsequent phone contact for patients not compliant with follow-up within 9 months of the initial visit.

![Fig. 1. Determination of complete abortion. Completed abortion was confirmed when participants followed one of the illustrated pathways. Red boxes indicate the endpoint of a pathway. hCG, human chorionic gonadotropin.](image-url)


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Patients were analyzed for the study outcome if they returned to the center or were reached by telephone within 9 months of the abortion; all others were considered lost to follow-up.

We also measured the proportion of patients with positive detection of products of conception (including both true- and false-positives), negative detection of products of conception (both true- and false-negatives), reaspirations, completed abortions, and ongoing pregnancies. Ongoing pregnancies were suspected when patients had one or both of the following indicators: 1) rising postoperative serum hCG levels in patients with no or incomplete products of conception identified or 2) ultrasound confirmation of ongoing pregnancy at any date after initial abortion. We performed a planned subgroup analysis of the primary outcome, true-positive identification of products of conception, in patients with sac size 3 mm or less including those with no visible sac on ultrasonography.

Based on a published report of early surgical abortion, in which 22% of patients with subsequent diagnosis of completed abortion had no or inadequate products of conception identified at the time of the abortion procedure, we estimated that electric vacuum aspiration has a true-positive proportion of 80%. To find a difference of 10% (manual vacuum aspiration true-positive proportion of 90%) with 80% power and two-tailed α of 0.05, we required a sample size of 199 per group (398 participants total). Based on published reports, we estimated that 3% of patients would have failed abortions (ongoing pregnancies); therefore, we required an additional six per group. We assumed a lost to follow-up proportion of 22%; therefore, we required an additional 44 patients per group for a total of 249 patients per group or 498 total.

Data were analyzed according to intention-to-treat principles. The study groups were compared for baseline characteristics using the $\chi^2$ or Wilcoxon rank-sum test. We used the Pearson $\chi^2$ test of likelihood ratios to assess the difference in sensitivity for the primary outcome variable (true-positive identification of products of conception) between the two groups. We used the Pearson $\chi^2$ test or the Fisher’s exact test for other dichotomous outcome variables including the proportion of positive detection of products of conception (true- and false-positive proportions), ongoing pregnancies, completed abortions, reaspirations, and requiring hCG follow-up. We used Cohen’s $\kappa$ coefficient, a statistical measure of interrater agreement, to compare physician identification of products of conception with medical assistant identification of products of conception to test for concordance between the two types of raters. We conducted a planned subgroup analysis of the earliest pregnancies with sac size 3 mm or less or absent. We calculated specificities, sensitivities, negative predictive values, and positive predictive values. We used SPSS 20 for all data entry and analysis. We calculated sensitivities, specificities, positive predictive values, and negative predictive values based on our findings. Specificity was analyzed as the correct determination of a completed abortion. Sensitivity was analyzed as the correct determination of an ongoing pregnancy (ie, noncompleted abortion).

**RESULTS**

We enrolled a total of 500 women from April 22, 2010, to October 14, 2011; 252 women were randomized to manual vacuum aspiration and 248 to electric vacuum aspiration (Fig. 2). Two patients were...
excluded after randomization: one for a screen failure (ultrasonogram on a previous date) and one because she changed her mind about study participation between randomization and the abortion procedure. Demographic and clinical characteristics are presented for the remaining 498 women: manual vacuum aspiration = 251 and electric vacuum aspiration = 247 (Table 1). All but two patients received abortions using only the aspirator to which they had been randomly assigned; in two abortions, the physician used manual vacuum aspiration when randomized to electric vacuum aspiration. There were no cases for which the physician used both aspirators. We found no significant difference between the manual and electric vacuum aspiration groups in the proportion of sacs measured using a single measurement or using the mean sac diameter (\(P = .87\)).

Sixty (12%) patients were lost to follow-up after the initial visit (29 manual vacuum aspiration and 31 electric vacuum aspiration, \(P = .74\), relative risk [RR] 1.05, 95% confidence interval [CI] 0.79–1.38). Of the 79 patients who required hCG levels to confirm completed pregnancy, six never returned for their second hCG level and were therefore among those lost to follow-up. Of the 438 remaining patients, 320 (64%) returned in person (161 manual vacuum aspiration and 159 electric vacuum aspiration) and 118 were followed up by phone (61 manual and 57 electric). There were no significant group differences for phone compared with in-person follow-up (\(P = .79\), RR 0.93, 95% CI 0.79–1.19).

In total, 438 patients (88%) were analyzed for the primary outcome: true-positive detection of products of conception by the physician. Data on the tissue inspection by the medical assistant were missing for 22 patients; therefore, 416 patients were analyzed for the comparative outcome: true-positive detection of products of conception by the blinded medical assistant.

The demographic and clinical characteristics of the women randomized to manual vacuum aspiration and electric vacuum aspiration did not differ significantly (Table 1). The mean gestational sac size for patients with a single measurement of sac length was 7.9 mm (standard deviation 2.3) and the mean of the mean sac diameter (calculated for patients with three sac measurements) was 7.9 mm (standard deviation 2.3), corresponding to 5 weeks 3 days of gestation. Sixty-two patients (12%) had sac size less than or equal to 3 mm on preprocedure ultrasonography; of these, 40 had no visible sac. Six patients had twin pregnancies detected on ultrasonogram. Fourteen physicians and 11 medical assistants participated in the study; the distribution of medical personnel did not vary significantly by study group. Physicians used size 6 and 7 cannulas (56% and 44% of the time, respectively). Physicians used ultrasonographic guidance to complete the abortion for 7% of patients. Ten patients underwent reaspiration immediately after the initial aspiration for undetected products of conception on gross inspection, by study group. Physicians used size 6 and 7 cannulas (56% and 44% of the time, respectively). Physicians used ultrasonographic guidance to complete the abortion for 7% of patients. Ten patients underwent reaspiration immediately after the initial aspiration for undetected products of conception on gross inspection,
six in the manual vacuum aspiration group and four in the electric vacuum aspiration group. In six of these, immediate reaspiration resulted in positive detection of products of conception; in the remaining four, serial hCG levels were consistent with completed abortion. Interrater reliability between physicians and medical assistants for identification of products of conception was high (90% agreement) with no difference between the raters’ rates of positive products of conception identification in either the manual or electric vacuum aspiration group (P=.39).

Manual and electric vacuum aspiration resulted in similarly high rates of true-positive detection of products of conception (positive products of conception detection in patients with completed abortion confirmed on follow-up) whether the tissue examination was performed by the unblinded physician or the blinded medical assistant. With physician assessment (Table 2), 82% of patients in the medical vacuum aspiration group had true-positive identification of products of conception compared with 76% of patients undergoing electric vacuum aspiration (P=.13, RR 0.83, 95% CI 0.64–1.07). With medical assistant assessment (Table 3), 83% of patients in the medical vacuum aspiration group had true-positive identification of products of conception compared with 79% of patients undergoing electric vacuum aspiration (P=.38, RR 0.90, 95% CI 0.69–1.16).

Rates of true-negative products of conception identification (no products of conception detected in patients subsequently found to have ongoing pregnancies) were low and similar between study groups; there were only three patients in whom the absence of products of conception on physician tissue inspection predicted ongoing pregnancy: one in the manual vacuum aspiration group and two in the electric vacuum aspiration group; medical assistants predicted two in each study group. We found high rates of false-negative results (no products of conception identified in patients with subsequently confirmed completed abortion); these were lower in the patients undergoing manual vacuum aspiration by physician inspection (15.8% compared with 23.1%) and similar with medical assistant inspections (15.5% compared with 19.7%). The rate of false-positive results (products of conception detected in patients found to have an ongoing pregnancy on follow-up) was low: physicians found four in the medical vacuum aspiration group and none in the electric vacuum aspiration group; medical assistants identified two in the medical vacuum aspiration group and none in the electric vacuum aspiration group. Statistical tests are shown in Tables 2 and 3, but interpretation is uncertain, especially for the true-negative and false-positive categories where cell sizes are small or zero, because we were not powered to test these outcomes.

Overall, physicians ordered hCG levels to confirm completed abortion in 17% of patients. They ordered hCG levels somewhat less often after using manual than electric vacuum aspiration (14% compared with 21%, P=.06, RR 1.29, 95% CI 0.69–1.69). On follow-up, we found that most patients had had successful terminations of pregnancy: 97% of patients undergoing manual and 96% of patients undergoing electric vacuum aspiration had changes in hCG levels consistent with completed abortion (P=.79, RR 0.72, 95% CI 0.06–8.27). Overall, the rate of ongoing pregnancies, whether products of conception were seen or not, was low; five (2.3%) patients undergoing manual vacuum aspiration and two (0.9%) patients undergoing electric

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Table 2. Comparison of Proportion of True-Positive, True-Negative, False-Negative, and False-Positive Tissue Inspections by Physicians* Among Women Randomized to Manual or Electric Vacuum Aspiration Before Surgical Abortion at Less Than 6 Weeks of Gestation

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Manual (n=222)</th>
<th>Electric (n=216)</th>
<th>Relative Risk (95% CI)</th>
<th>P†</th>
</tr>
</thead>
<tbody>
<tr>
<td>True-positive‡</td>
<td>182 (82)</td>
<td>164 (75.9)</td>
<td>0.83 (0.64–1.07)</td>
<td>.13</td>
</tr>
<tr>
<td>True-negative§</td>
<td>1 (0.5)</td>
<td>2 (0.9)</td>
<td>1.52 (0.31–7.57)</td>
<td>.62</td>
</tr>
<tr>
<td>False-negative¶</td>
<td>35 (15.8)</td>
<td>50 (23.1)</td>
<td>1.28 (0.98–1.69)</td>
<td>.05</td>
</tr>
<tr>
<td>False-positive†</td>
<td>4 (1.8)</td>
<td>0</td>
<td>0.50 (0.46–0.55)</td>
<td>.12</td>
</tr>
</tbody>
</table>

Cl, confidence interval.
Data are n (%) unless otherwise specified.
* Physicians were not blinded to study group assignment.
† Pearson χ² or Fisher’s exact test if cell size is less than five.
‡ True-positive=no products of conception identified in patients with subsequently confirmed completed abortion.
§ True-negative=no products of conception identified in patients with subsequently confirmed ongoing pregnancies or incomplete abortions.
¶ False-negative=no products of conception identified in patients with subsequently confirmed completed abortion.
† False-positive=products of conception identified in patients with subsequently confirmed ongoing pregnancies or incomplete abortions.
Table 3. Comparison of Proportion of True-Positive, True-Negative, False-Negative, and False-Positive Tissue Inspections by Medical Assistants* Among Women Randomized to Manual or Electric Vacuum Aspiration Before Surgical Abortion at Less Than 6 Weeks of Gestation

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Manual (n=213)</th>
<th>Electric (n=203)</th>
<th>Relative Risk (95% CI)</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>True-positive</td>
<td>176 (82.6)</td>
<td>161 (79.3)</td>
<td>0.90 (0.69–1.16)</td>
<td>.38</td>
</tr>
<tr>
<td>True-negative</td>
<td>2 (0.9)</td>
<td>2 (1.0)</td>
<td>1.02 (0.38–2.47)</td>
<td>1.0</td>
</tr>
<tr>
<td>False-negative</td>
<td>33 (15.5)</td>
<td>40 (19.7)</td>
<td>1.16 (0.89–1.52)</td>
<td>.30</td>
</tr>
<tr>
<td>False-positive</td>
<td>2 (3.6)</td>
<td>0</td>
<td>0.51 (0.46–0.56)</td>
<td>.50</td>
</tr>
</tbody>
</table>

CI, confidence interval.

* Medical assistants were blinded to study group assignment. Medical assistants did not evaluate 22 cases.
† Pearson χ² or Fisher’s exact test (if cell size is less than five).
§ True-positive=products of conception identified in patients with subsequently confirmed completed abortion.
¶ True-negative=no products of conception identified in patients with subsequently confirmed ongoing pregnancies or incomplete abortions.
¶¶ False-negative=no products of conception identified in patients with subsequently confirmed completed abortion.
** False-positive=products of conception identified in patients with subsequently confirmed ongoing pregnancies or incomplete abortions.

vacuum aspiration (P=.45, RR 0.703, 95% CI 0.436–1.134). This count included one patient with positive products of conception by both physician and medical assistant inspection who was treated at an outside facility 14 days after her abortion for a presumed ectopic pregnancy on the basis of pelvic pain and an elevated hCG level; however, ectopic pregnancy was not confirmed by serial hCG levels, ultrasonography, or pathology; she was analyzed as a false-positive result. We found no other ectopic or presumed ectopic pregnancies. Even with the earliest pregnancies, manual and electric vacuum aspiration resulted in similar rates of true-positive products of conception detection by physician inspection, although the rates of positive detection were considerably lower in this subgroup than in the study population as a whole. In pregnancies of sac size 3 mm or less, including those with no visible sac, five (17%) of 29 patients undergoing manual vacuum aspiration had accurate identification of products of conception compared with four (13%) of 31 patients undergoing electric vacuum aspiration (P=.64, RR 0.85, 95% CI 0.44–1.63).

Complications were rare. One patient experienced a uterine perforation managed with observation. No patients experienced hemorrhage or cervical laceration requiring suture, required transfer, or presented with signs of infection at follow-up.

Based on the results of the tissue examinations performed by the blinded medical assistants, the specificity of manual vacuum aspiration for correct identification of completed abortion was 84% and the specificity of electric vacuum aspiration was 80%. The sensitivity of manual vacuum aspiration for correct identification of incomplete abortion was 50% and the sensitivity of electric vacuum aspiration was 100%.

The negative predictive value [the ability of a normal result [products of conception identified] to predict a normal outcome [completed abortion]] of manual vacuum aspiration was 99% and of electric vacuum aspiration was 100%. The positive predictive value [the ability of an abnormal result [no or incomplete products of conception] to predict an abnormal outcome [ongoing pregnancy]] of manual vacuum aspiration was 6% and of electric vacuum aspiration was 5% (Table 4).

**DISCUSSION**

In this randomized trial, early surgical abortion had high efficacy (98–99%), and most abortions were complete whether or not the examiner identified products of conception on postoperative tissue inspection. Manual and electric vacuum aspiration were comparable for producing uterine aspirates that allowed for accurate identification of completed abortion. The study confirmed that appropriately trained medical assistants can identify products of conception in fresh tissue aspirates with accuracy rivaling physicians. Our findings add to a body of evidence showing that manual vacuum aspiration has no advantages over electric vacuum aspiration for first-trimester abortion.\(^{11}\) We found that aspiration abortion, using either manual or electric vacuum aspiration, can safely be offered to women at less than 6 weeks of gestation. The inconveniences of early aspiration, including hCG monitoring for some patients, must be weighed against patient benefits, including less time to resolution of undesired pregnancy.

Manual and electric vacuum aspiration were comparable for accurate identification of completed abortion even for the earliest pregnancies with no visible sac or sac size less than 3 mm on preoperative...
The specificities for determination of completed abortion were high and comparable for manual and electric vacuum aspiration. The small number of ongoing pregnancies in our sample limited our ability to accurately calculate sensitivities for determination of incomplete abortion. We found no difference between manual and electric vacuum aspiration in true-negative (no products of conception identified in women with completed abortion) and false-positive (products of conception identified in women with ongoing pregnancy) results. Physicians were somewhat less likely to have false-negative results (no products of conception identified in patients with subsequently confirmed completed abortion) after manual vacuum aspiration, but blinded medical assistants had no difference in false-negative results. Although our study was not powered for these analyses, our findings suggest that manual and electric vacuum aspiration are similar with respect to tissue inspection results.

The overall rates of completed abortion, ongoing pregnancy, and hCG level monitoring in our study were consistent with the small body of published literature on the topic of early abortion. Paul et al\(^5\) found an ongoing pregnancy rate of 1.5% for the total study population and 2.3% for women with follow-up and a 97% rate of complete abortion in procedures performed with manual or electric vacuum aspiration. Edwards and Carson,\(^1\) using manual vacuum aspiration only, found that 6% of their sample required hCG monitoring. Unlike these published works, we had no definite ectopic pregnancies in our study. A search of MEDLINE (English language 1990–2014 search terms “abortion” and “manual aspiration”) revealed no previously published work comparing manual with electric vacuum aspiration for early surgical abortion.

Our study’s strengths include randomization, a large number of patients, and rigorous follow-up. When calculating sensitivity and specificity, a test (in our case, tissue examination after aspiration with either manual or electric vacuum aspiration) is compared with a “gold standard” test. There is no single gold standard test to confirm completed abortion or ongoing pregnancy. We believe our thorough follow-up and multiple methods of ascertainment of ongoing pregnancy or completed abortion resulted in a high standard of accuracy. Our results are limited by the fact that the physicians were not blinded to study group assignment and may have been biased when they reported results of tissue inspections. In particular, physicians may have been more confident in their

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**Table 4. Specificity, Sensitivity, Negative Predictive Value, and Positive Predictive Value of Manual and Electric Vacuum Aspiration for Determination of Complete or Incomplete Surgical Abortion at Less Than 6 Weeks of Gestation Based on Tissue Inspection Results of Blinded Medical Assistants**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Manual (n=213)</th>
<th>Electric (n=203)</th>
<th>Relative Risk (95% CI)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specificity(^a)</td>
<td>84</td>
<td>80</td>
<td>1.01 (0.93–1.09)</td>
<td>.80</td>
</tr>
<tr>
<td>Sensitivity(^a)</td>
<td>50</td>
<td>100</td>
<td>0.50 (0.43–0.57)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>NPV(^b)</td>
<td>99</td>
<td>100</td>
<td>0.99 (0.98–1.00)</td>
<td>.26</td>
</tr>
<tr>
<td>PPV(^b)</td>
<td>6</td>
<td>5</td>
<td>0.99 (0.94–1.00)</td>
<td>.75</td>
</tr>
</tbody>
</table>

CI, confidence interval; NPV, negative predictive value; PPV, positive predictive value.

Data are % unless otherwise specified.

\(^a\) Specificity = true-positive/(true-positive+false-negative) = the ability of a test to identify correctly those who do not have the disease or characteristic of interest; thus, the probability that the tissue inspection result was normal (products of conception identified) in a patient with a completed abortion.

\(^b\) Sensitivity = true-negative/(false-positive+true-negative) = the ability of a test to identify correctly those who have a disease or characteristic of interest; thus, the probability that the tissue inspection result was abnormal (no products of conception identified) in a patient with an incomplete abortion.

\(^c\) PPV = true-positive/(true-positive+false-positive) = the ability of a normal result (products of conception identified) to predict a normal outcome (completed abortion).

\(^d\) NPV = true-negative/(true-negative+false-negative) = the ability of an abnormal result (no or incomplete products of conception) to predict an abnormal outcome (ongoing pregnancy).

\(^e\) We defined “positive products of conception” as a normal (negative) result and “no, incomplete, or uncertain products of conception” as an abnormal (positive) result for the purposes of calculating specificity, sensitivity, NPV, and PPV.

Ultrasonogram. However, overall rates of accurate products of conception detection were much lower with these extremely early pregnancies, and we found greater need for hCG monitoring in this subgroup. Three of the four false-positive results occurred in this subgroup. Our study was not powered to evaluate statistical differences in this subgroup, but these data may provide some guidance for future studies of very small or absent gestational sacs. Nevertheless, these findings highlight the need for routine postabortion follow-up of women with sac size 3 mm or less or absent to rule out ongoing pregnancy.

The specificities for determination of completed abortion were high and comparable for manual and electric vacuum aspiration. The small number of ongoing pregnancies in our sample limited our ability to accurately calculate sensitivities for determination of incomplete abortion. We found no difference between manual and electric vacuum aspiration in true-negative (no products of conception identified in women with completed abortion) and false-positive (products of conception identified in women with ongoing pregnancy) results. Physicians were somewhat less likely to have false-negative results (no products of conception identified in patients with subsequently confirmed completed abortion) after manual vacuum aspiration, but blinded medical assistants had no difference in false-negative results. Although our study was not powered for these analyses, our findings suggest that manual and electric vacuum aspiration are similar with respect to tissue inspection results.
detection of products of conception after use of manual vacuum aspiration and less so after use of electric vacuum aspiration as a result of an assumption that manual vacuum aspiration causes less disruption of evacuated tissue and therefore more likely to read the result as negative and order hCG levels after electric vacuum aspiration. Even with possible physician bias, we found no difference in the rates of the primary outcome by aspirator type, and interrater reliability between physicians and blinded medical assistants was high. Moreover, the medical assistants showed no difference in the rates of any outcome by aspirator type.

We found that manual and electric vacuum aspiration were comparable for producing uterine aspirates that allowed for accurate identification of products of conception in very early abortion. Physicians and other health care providers of abortion can confidently use either aspirator for early surgical abortion. Early aspiration is highly effective, although hCG monitoring may be necessary to confirm complete abortion.

REFERENCES