Instructions

1. Review the stated learning objectives at the beginning of the CME article and determine if these objectives match your individual learning needs.
2. Read the article carefully. Do not neglect the tables and other illustrative materials, as they have been selected to enhance your knowledge and understanding.
3. The following quiz questions have been designed to provide a useful link between the CME article in the issue and your everyday practice. Read each question, choose the correct answer, and record your answer on the CME Registration Form at the end of the quiz.
4. Type or print your full name and address and your date of birth in the space provided on the CME Registration Form.
5. Indicate the total time spent on the activity (reading article and completing quiz). Forms and quizzes cannot be processed if this section is incomplete. All participants are required by the accreditation agency to attest to the time spent completing the activity.

6. Complete the Evaluation portion of the CME Registration Form. Forms and quizzes cannot be processed if the Evaluation portion is incomplete. The Evaluation portion of the CME Registration Form will be separated from the quiz upon receipt at OrthoPEDIACS. Your evaluation of this activity will in no way affect the scoring of your quiz.
7. Send the completed form, with your $15 payment (check or money order in US dollars drawn on a US bank, or credit card information) to: OrthoPEDIACS CME Quiz, PO Box 36, Thorofare, NJ 08086, OR take the quiz online. Visit www.Healio.com/EducationLab/Orthopedics for details.
8. Your answers will be graded, and you will be advised whether you have passed or failed. Unanswered questions will be considered incorrect. A score of at least 90% is required to pass.
9. Be sure to mail the CME Registration Form on or before the deadline listed. After that date, the quiz will close. CME Registration Forms received after the date listed will not be processed.

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ABSTRACT

Use of closed drainage systems after total knee arthroplasty (TKA) is a routine practice. Currently, a debate exists regarding whether temporary or no clamping is optimal. A systematic review of the English literature was conducted, and randomized controlled trials comparing all forms of temporary or no clamping drainage were included. Two authors independently extracted articles and predefined data. Data were pooled using a fixed-effects model to perform the meta-analysis. Nine randomized controlled trials totaling 850 patients were retrieved. The results indicate that temporary clamping could significantly reduce the drainage volume, including total drain-
age volume, drainage volume within 24 hours postoperatively, and drainage volume within 48 hours postoperatively. Furthermore, patients treated with temporary drainage clamping for 4 hours or more had a higher hemoglobin level 24 hours postoperatively than the patients treated with no clamping, and the number of blood transfusions per patient decreased significantly. No significant difference was identified between the 2 practices regarding postoperative range of motion, wound-related complications, and deep vein thrombosis. More randomized controlled trials are needed to provide robust evidence and to definitively determine which practice is most effective in reducing postoperative blood loss.

Total knee arthroplasty (TKA) is routinely used to treat end-stage knee osteoarthritis. It is well tolerated, and, in correctly selected patients, the results are satisfactory in a high portion of patients. However, significant blood loss after TKA can occur. Transfusions have substantial complication risks, such as immunological reactions, disease transmission, transfusion-associated circulatory overload, transfusion-related acute lung injury, real failure, and transfusion-induced coagulopathy, and should be avoided if possible. Many blood-conserving measures have been developed to reduce blood loss and postoperative transfusion rates.

Use of no clamping drainage systems after TKA is controversial. Theoretically, no clamping drainage systems can decrease hematoma formation and, therefore, are believed to help decrease postoperative pain, swelling, and infection. Although many studies have shown no advantage of no clamping drainage systems after TKA, it is still a routine procedure widely used by orthopedic surgeons. Recently, temporary drainage clamping has been used. Proponents of temporary drainage clamping believe that temporarily clamping the drainage tube can create a tamponade effect; thus, it can control the bleeding effectively. Many prospective randomized controlled trials and retrospective clinical trials have been performed to evaluate this procedure, but no consensus has been achieved to date. Currently, several randomized controlled trials have compared the 2 procedures. The authors conducted a systematic review and meta-analysis to compare the intra- and postoperative outcomes reported in randomized studies of temporary vs no clamping drainage in patients undergoing TKA to determine which system is optimal.

**MATERIALS AND METHODS**

**Search Strategy**

A systematic literature review was independently performed by 2 authors (Z.H., J.M.) using the PubMed, Medline, Embase, and Cochrane databases and Google Scholar for all peer-reviewed studies published between 1990 and 2012 to find all randomized controlled trials comparing temporary vs no clamping drainage in patients undergoing TKA. Only English-language articles were selected, and the last search of the databases occurred on October 30, 2012. The related articles feature was used in PubMed to broaden the search of the database. The following keywords were used to search all databases: knee, arthroplasty, replacement, TKA, THR, clamping/temporal, and clamping/delayed releasing.

**Eligibility Criteria and Data Extraction**

Two reviewers (Z.H., J.M.) independently identified titles and abstracts that were relevant to temporary and no clamping drainage in patients treated with unilateral TKA for symptomatic knee disease. Full text of the published and unpublished articles and unpublished data of completely finished and analyzed studies were included. The references lists of the full-text articles were also reviewed. If relevant information was specified, the authors were contacted for unpublished data. To be included in the analysis, studi-
ies had to compare temporary and no clamping drainage in patients undergoing unilateral TKA for symptomatic knee disease and be a published randomized controlled trial. Exclusion criteria were as follows: the outcomes of interest were not reported for the 2 approaches; it was impossible to extrapolate or calculate the necessary data from the published results; and studies contained previously published data.

The 2 authors independently extracted the data on a standard form that contained general information (eg, authors, publication year), patients’ demographics, indication for TKA, different interventions, clinical outcomes, and complications. Discrepancies were resolved by consensus after discussion, and a third reviewer (J.Y.) was consulted if necessary.

### Quality Assessment of the Included Studies

The methodological quality of the trials was assessed independently. The quality of the studies was assessed by using the modified Jadad scale (Table 1). Studies achieving 4 or more points (from a maximum of 8) were considered to be of high quality. Discrepancies were resolved by consensus after discussion, and a third reviewer was consulted if necessary.

### Statistical Analysis

The meta-analysis was performed using the Cochrane Collaboration and the Quality of Reporting of Meta-analysis guidelines. For continuous outcome data, such as operative time and in-hospital stays, means and SDs were used to calculate the mean difference and 95% confidence intervals (CIs). For dichotomous outcomes, such as intra- and postoperative complications, the risk ratio (RR) and 95% CI were calculated as the summary statistics. All results were reviewed for clinical and statistical heterogeneity. Clinical heterogeneity was evaluated based on the study populations and interventions, the definition of outcome measures, concomitant treatment, and perioperative management. Heterogeneity was determined by chi-squared test. A *P* value of .10 was considered a significant difference, and I values were used for the evaluation of statistical heterogeneity (an I value of 50% or more indicated the presence of heterogeneity). A fixed-effects model was used to synthesize data when heterogeneity was absent; otherwise, a random-effects model would have been used. Data were presented as a forest plot. Analyses were conducted using Review Manager version 5.0 software for Windows (The Nordic Cochrane Centre, The Cochrane Collaboration, Oxford, England).

### RESULTS

#### Literature Search Results

Articles and their references published between 1990 and 2012 were reviewed. The search strategy retrieved 324 studies after examining the titles and abstracts and reading the full text; 9 articles met the predefined inclusion criteria (Figure 1).

A total of 850 patients (850 knees) were included in the 9 trials: 414 knees in the temporary clamping drainage group and 436 knees in the no clamping drainage group. Table 2 summarizes the baseline characteristics of the included trials. Patients’ demographics were compared in each trial.

### Methodological Quality Assessment

The modified Jadad scores of the 9 articles are summarized in Table 2. The total scores show that the quality of the 9 trials is high, with a minimum of 4 points and a maximum of 7 points. Because these trials are all therapy trials, they can only be single-blind, which may bring a certain detection bias to the results.

### Meta-analysis

#### Drainage Volume

Eight of the included studies provided data on total drainage volume. The meta-analysis of the total drainage volume illustrated the significant decrease of the total drainage volume in the temporary clamping group (mean difference, −318.12; 95% CI, −378.41 to −241.99; *P*<.0001; I=79%) (Figure 2A). The drainage volume was assessed at different time points. The results were compared for drainage volume available at 24 (group 1) and 48 (group 2) hours postoperatively. The drainage volume was significantly higher in both groups (group 1: mean difference, −398.46; 95% CI, −457.61 to −329.32; *P*=.03; I=71%) (Figure 2B) (group 2: mean difference,
ing data illustrated no difference in hemoglobin levels 48 hours postoperatively between the 2 groups (mean difference, −0.01; 95% CI, −0.28 to 0.26; \( P=.52; I=0\%\)) (Figure 4B).

Postoperative Range of Motion. Data on 537 knees (260 using temporary clamping drainage and 277 using no clamping drainage) were pooled from 6 trials,\textsuperscript{12,14,17,20} No significant differences emerged between the groups with respect to the postoperative range of motion (mean difference, 1.58; 95% CI, −0.48 to 3.64; \( P=.58; I=0\%\)) (Figure 5A).

Complications

Based on the available data, the complications were divided into wound-related complications and deep vein thrombosis (DVT). The wound-related complications included ooze, blistering, cellulitis, bruising, and superficial infection. Data on 703 knees were pooled from 7 trials analyzing wound-related complications.\textsuperscript{12-15,17,18,20} A total of 27 wound complications occurred in the temporary clamping group compared with 19 in the no clamping group. No difference was found between the groups with respect to wound-related complications (RR = 1.60, 95% CI, 0.93 to 2.77; \( P=.10; I=46\%\)) (Figure 5B). Data for incidences

Table 2

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Abbreviation: NA, not available.

\textsuperscript{a}Postoperative hours.

\textsuperscript{b}The drains were clamped for 3 hours, released for 3 hours, reclamped for 3 hours, and then the clamp was run continuously.

\textsuperscript{c}The drains were left clamped for all but 5 minutes (or 100 mL drainage) every 2 hours for the first 6 hours, then at 12- and 24-hour periods.

\textsuperscript{d}With 30 mL saline and 1:500,000 adrenaline injection.

Postoperative Hemoglobin Levels. Data for hemoglobin levels 24 hours postoperatively were provided in 6 trials, 3 reporting temporary clamping for less than 4 hours,\textsuperscript{12,16,20} and 3 reporting temporary clamping for 4 hours or more.\textsuperscript{14,17,18} A subgroup analysis was undertaken. The results showed no significant difference in hemoglobin levels 24 hours postoperative between the no clamping and temporary clamping groups (Figure 3A). The subgroup analysis revealed that the patients in the temporary clamping group could have a significantly higher hemoglobin levels 24 hours postoperatively than the patients in the no clamping group (mean difference, 0.37; 95% CI, −0.37 to 0.77; \( P=.96; I=0\%\)) (Figure 3B).

Number of Transfusions per Patient. Data on the number of transfusions per patient were available in 4 studies.\textsuperscript{12,15-17} The number of blood transfusions per patient was significantly less in the temporary clamping group compared with the no clamping group (mean difference, −0.37; 95% CI, −0.57 to −0.16; \( P=.0004; I=0\%\)) (Figure 4B).

Number of Patients Needing Transfusions. Data on the number of patients who needed transfusion were available in 5 studies.\textsuperscript{13,15,17,20} Only 1 study found a significant difference between the 2 groups, and it favored no clamping.\textsuperscript{17} whereas the others did not detect a significant difference. Pooling the data indicated that a smaller number of patients needed transfusions in the temporary clamping group, although the difference did not reach significance (Figure 4B).
of DVT were recorded in 6 trials, indicating that 8 of 489 patients experienced DVT postoperatively and that each group had 4 patients with DVT. No differences were detected between the groups (RR = 1.14; 95% CI, 0.31 to 4.28; P = .33; I² = 0%) (Figure 5C). Two patients in the no clamping group who developed pulmonary embolism were reported in 2 trials.

**Discussion**

The reduction of blood loss after TKA is a long-standing problem. Using a drainage system is a routine practice, although it is controversial. Two major drainage strategies are used: temporary or no clamping drainage. Supporters of no clamping drainage believe that it cannot only prevent hematomas and minimize the undesirable accumulation, but it can also provide a better wound outcome. In addition, it may reduce deep infections, resulting in better knee function and fewer complications. However, proponents of temporary clamping believe that temporary drainage clamping can help reduce blood loss after TKA and decrease the transfusion rate. Therefore, the authors conducted a systematic review of the literature and a subsequent meta-analysis based on the available data.

The current study indicates that temporary clamping could significantly reduce the blood loss volume, including total drainage volume and drainage volume at both 24 and 48 hours postoperatively. Furthermore, patients treated with temporary drainage clamping for 4 hours or more had higher hemoglobin levels 24 hours postoperatively, and temporary drainage clamping significantly reduced the number of blood transfusions per patient. Although no significant differences were detected between the 2 groups regarding the number of patients needing transfusions, the meta-analysis results indicate a trend of a smaller number of such patients in the temporary clamping group.

Multiple drainage strategies can be used after TKA, but the core concept behind these strategies is to decrease hematoma formation and minimize blood loss. To reach this goal, an ideal drainage strategy must exist that can maintain the balance between a tamponade effect and wound complications. Most of the blood loss, in TKA occurs during the first few postoperative hours, so this period is essential for blood loss control.
Theoretically, the temporary clamping strategy provides a tamponade effect initially after TKA that can reduce the amount of blood loss and delayed unclamping can avoid hematoma formation.

However, how long the temporary clamping should last is debated. Generally, the drain clamping technique can be classified into 2 patterns: a single period of temporary clamping (ranging from 1 to 24 hours postoperatively) and an intermittent or interval clamping pattern that switches between clamping and unclamping periods.

In the current study, a subgroup analysis done based on the different clamping period indicated that patients had a significantly higher hemoglobin level 24 hours postoperatively when using temporary clamping for 4 hours or more. Three trials were included in the positive subgroup, of which 2 used temporarily clamping for 4 hours and 1 used temporary clamping for 1 hour. The temporary clamping group had a smaller number of transfusions per person than the no clamping group. These findings are similar to those of Jou et al, who found that most blood loss occurs during the first few postoperative hours. Temporary clamping for 4 hours or more can help reduce most blood loss after TKA. However, only 2 trials provided hemoglobin levels 48 hours postoperatively, which may explain why no benefit was found in the temporary clamping group.

Five trials provided data on postoperative range of motion. The pooled data showed no significant difference between the 2 groups. The temporary clamping time of these 5 trials ranged from 0.5 to 4 hours, which could indicate that the knee swelling caused by clamping had a limited effect on postoperative range of motion by controlling the clamped time in a proper limitation. In addition, a well-performed postoperative rehabilitation program could also reduce the effect.

One potential problem with clamping drains is wound-related complications. Some surgeons claimed that the rate of wound-related complications was much higher in the temporary clamping group.
than those in the no clamping group. However, this result was only observed in 1 trial, and the pooled data failed to detect the difference between the 2 groups. Deep vein thrombosis is one of the most common complications after TKA and can result in morbidity and mortality. The current study revealed no difference between the 2 groups with regard to DVT. Although the methods of DVT prophylaxis were different between the trials, no heterogeneity was detected. The total rate of DVT is 1.6% (1.7% in the temporary clamping group and 1.6% in the no clamping group), which is similar to that reported in other studies. Only 2 of 4 patients with DVT in the no clamping group developed a pulmonary embolism. The total rate of pulmonary embolism is 0.04%, which is similar to that reported in the other study. Because of the low morbidity, data on pulmonary embolisms were not pooled for the current study.

A systematic review of temporary clamping drainage for unilateral TKA by Tai et al included only 6 trials. The power of the current meta-analysis compared with Tai et al was increased by several factors. First, more trials were searched and included for analysis. Four high-quality randomized controlled trials were included in this study. One trial included in the Tai et al study was excluded in the current study because it was not considered a randomized controlled trial. Second, narrow CIs around the point estimates and higher quality of the trials result in more precise estimates of treatment effects. Third, more measures of efficacy and risk were compared, including hemoglobin levels 24 and 48 hours postoperatively, the number of transfusions per patient, the number of patients needing transfusion, and the number of DVT incidences. Not only did the current authors find that the patients in the temporary clamping group had a significantly higher hemoglobin level 24 hours postoperatively when temporary clamping for 4 hours or more was used, which was also observed by Tai et al, but they also found that temporary clamping could significantly reduce the number of transfusions per patient. In addition, the current authors detected a trend of a smaller number of patients who needed transfusions in the temporary clamping group, although the difference was not significant.

Some limitations of the current meta-analysis warrant discussion. First, the modified Jadad score, which is designed for analysis of randomized controlled trials, was used to evaluate the included trials. The assessment showed that the weakness of the included trials lay in the poor description of the blinding methods and poor description of the method used to assess adverse effects. Second, some of the studies reported the continuous data without SDs. Although the current authors tried to contact the study authors to get the information, the missing data could not be obtained; thus, these data could not be fully used. Third, some parameters that could also be used to compare these 2 clamping practices, such as postoperative swelling, patients’ satisfaction, postoperative knee scores, and pain relief, could not be analyzed because of the different standards used in the trials.

Despite the abovementioned limitations, the current meta-analysis has provided the best evidence on the temporary drainage clamping strategy after TKA at this point in time. This study indicates that temporary drainage clamping for 4 hours or more could have a result in a higher hemoglobin level 24 hours postoperatively and reduce the number of transfusions per patient postoperatively. Therefore, based on the current findings, using temporary clamping drainage after TKAs can have more benefits than using no clamping. More high-quality randomized controlled trials are needed to provide robust evidence and to confirm this drainage option is the best option.

REFERENCES


