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The modified squeeze maneuver for contrast medium extravasation: A radiological validation study

Kontrast madde ekstravazasyonunda modifiye sıkma manevrası: Radyolojik doğrulama çalışması

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ABSTRACT

Aim: Contrast medium extravasation (CME) is an increasingly encountered complication of contrast-enhanced computed tomography, particularly with the widespread use of automatic pressure injectors. Although most cases resolve conservatively, severe events such as tissue necrosis and acute compartment syndrome may occur, and no standardized treatment algorithm exists. We evaluated the safety and effectiveness of a modified percutaneous squeeze maneuver designed to facilitate early contrast evacuation.

Material and Methods: This retrospective case series included 18 adult patients with CME treated between 2019 and 2023. The technique consisted of multiple percutaneous punctures advanced to the fascial plane in a predefined geometric pattern, followed by controlled peripheral-to-central compression. Outcomes included radiologic clearance, pain reduction using the Visual Analog Scale (VAS), functional recovery using the Quick Disabilities of the Arm, Shoulder, and Hand (Quick-DASH) questionnaire at 6 months, and complications.

Results: Radiologic clearance was observed in all included patients. Mean VAS scores decreased significantly from 7.11 ± 1.23 to 1.44 ± 0.92 after the intervention (Wilcoxon signed-rank test, $p < 0.001$). Functional outcomes were excellent, with a mean Quick-DASH score of 2.02 ± 4.33 and a median of 0. No procedure-related complications were observed.

Conclusion: The modified squeeze maneuver is a simple, low-cost, and minimally invasive technique that provides rapid symptom relief, effective contrast evacuation, and excellent functional outcomes, representing a practical alternative between conservative observation and surgical intervention.

Keywords: Contrast medium extravasation, percutaneous drainage, squeeze maneuver, minimally invasive treatment, radiologic validation

ÖZ

Amaç: Kontrast madde ekstravazasyonu (KME), özellikle otomatik basınçlı enjektörlerin yaygın kullanımıyla birlikte kontrastlı bilgisayarlı tomografinin giderek daha sık karşılaşılan bir komplikasyonudur. Çoğu olgu konservatif olarak düzelmekle birlikte doku nekrozu ve akut kompartman sendromu gibi ciddi olaylar görülebilir ve standart bir tedavi algoritması bulunmamaktadır. Erken kontrast boşaltımını kolaylaştırmak üzere tasarlanmış modifiye perkütan sıkma manevrasının güvenliği ve etkinliğini değerlendirdik.

Gereç ve Yöntemler: Bu retrospektif olgu serisine 2019–2023 yılları arasında KME nedeniyle tedavi edilen 18 erişkin hasta dahil edildi. Teknik; önceden tanımlanmış geometrik bir düzende fasya planına ilerletilen çoklu perkütan ponksiyonlar ve ardından kontrollü periferden merkeze kompresyondan oluşuyordu. Sonlanımlar; radyolojik temizlenme, Vizüel Analog Skala (VAS) kullanılarak ağrı azalması, 6. ayda Quick Disabilities of the Arm, Shoulder, and Hand (Quick-DASH) anketi ile fonksiyonel iyileşme ve komplikasyonları içeriyordu.

Bulgular: Tüm hastalarda radyolojik temizlenme sağlandı. Ortalama VAS skorları 7,11 ± 1,23'ten 1,44 ± 0,92'ye anlamlı olarak azaldı (ortalama azalma 5,67 ± 0,84; $p < 0,001$). Fonksiyonel sonuçlar mükemmeldi; ortalama Quick-DASH skoru 2,02 ± 4,33 ve medyan 0 idi. İşleme bağlı komplikasyon gözlenmedi.

Sonuç: Modifiye sıkma manevrası; hızlı semptom rahatlaması, etkili kontrast boşaltımı ve mükemmel fonksiyonel sonuçlar sağlayan, basit, düşük maliyetli ve minimal invaziv bir tekniktir ve konservatif izlem ile cerrahi girişim arasında pratik bir alternatif oluşturmaktadır.

Anahtar Kelimeler: Kontrast madde ekstravazasyonu, perkütan drenaj, sıkma manevrası, minimal invaziv tedavi, radyolojik doğrulama

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Highlights

- Radiographic clearance was observed in all included cases following the modified squeeze maneuver.
- Pain decreased markedly after the procedure (mean VAS reduction: 5.67 points).
- Excellent 6-month function was observed (median Quick-DASH: 0).
- The technique is low-cost, bedside applicable, and requires no operative infrastructure.
- No procedure-related complications occurred in this series.

INTRODUCTION

Iodinated contrast agents are routinely used in computed tomography (CT) to enhance visualization of anatomical structures and improve diagnostic accuracy (1). These agents may be administered manually or through automatic pressure injectors, which provide standardized contrast delivery at high pressures, reduce radiation exposure for staff, and improve image quality (1-3). However, the increasing use of pressure injectors has been associated with a higher incidence of contrast medium extravasation (CME), with reported rates ranging from 0.5% to 0.9% (4-6).

Although most CME events result in mild local swelling and inflammation, larger or deeper extravasations may spread along fascial planes, increase intracompartmental pressure, and in rare cases lead to tissue necrosis or acute compartment syndrome (ACS) (6). Despite this potential severity, there is no clear consensus regarding optimal management. Conservative approaches such as limb elevation and observation are commonly employed (4,6-8), whereas invasive methods including aspiration, saline irrigation, liposuction, or fasciotomy are generally reserved for severe or high-volume cases (9-12).

In 2007, Tsai et al. described the “squeeze maneuver,” a minimally invasive technique intended to evacuate extravasated contrast material (13). Although promising, the method lacked procedural standardization, radiologic confirmation of evacuation, and objective functional outcome assessment.

We therefore developed a modified percutaneous squeeze maneuver incorporating systematic fascial-level punctures, geometric standardization, and radiologic and functional validation. This study aimed to evaluate the safety and effectiveness of this modified technique in patients with CME.

MATERIAL and METHODS

This retrospective case series included patients who developed contrast medium extravasation during contrast-enhanced computed tomography (CT) examinations performed at our institution between 2019 and 2023. Patients who were referred to the orthopedics and traumatology department and treated with the modified squeeze maneuver were eligible for inclusion.

Ethical approval was obtained from the Karabük University Ethics Committee (Approval number: 2023/1485), and written informed consent was obtained from all participants.

All patients aged ≥18 years were included. Patients younger than 18 years (n = 2) were excluded. No additional exclusion criteria were applied.

All contrast-enhanced CT examinations were performed using an automatic contrast injector system (Imaxeon Avida, Sydney, Australia), operating at flow rates of 1.5–6 mL/min and pressures of 250–300 psi.

Extravasation was suspected when patients reported pain or swelling at the infusion site following imaging and was confirmed radiographically using plain radiographs. After confirmation, the orthopedics team was consulted. During the initial assessment, distal circulation and neurovascular status of the affected extremity were evaluated. The estimated volume of extravasated contrast medium was calculated by subtracting the remaining volume in the injector from the initial loaded volume.

After detailed counseling and informed consent, the intervention was performed under sterile conditions in the emergency department. No local anesthesia or procedural sedation was administered during the intervention. A minimally invasive evacuation technique was applied using a 20-gauge needle. Multiple percutaneous punctures were advanced down to the fascial plane to facilitate drainage of the contrast material. Three longitudinal rows (medial, central, and lateral) were created, each containing five punctures, resulting in a total of 15 fascial punctures arranged in a predefined geometric pattern. Approximately 0.5 cm spacing was maintained between puncture sites to improve procedural reproducibility and facilitate homogeneous drainage of the extravasated contrast material. Minor adjustments in puncture spacing were made according to the degree of swelling and anatomical constraints of the involved region. Particular attention was paid to superficial anatomical landmarks during fascial-level advancement to minimize the risk of cutaneous or neurovascular injury.

Manual peripheral-to-central compression ("squeezing") was subsequently applied to express the extravasated contrast through the puncture sites. Figure 1 illustrates the procedural steps, and Figure 2 demonstrates representative pre- and post-procedural radiographs confirming radiologic clearance.

Patients were monitored before and after the procedure for signs of acute compartment syndrome. A resting splint was applied for 24 hours to limit movement and soft tissue swelling. Hand or wrist involvement was managed with a short-arm splint, whereas forearm or elbow involvement required a long-arm splint.

Radiographic evaluation was performed immediately after the procedure and repeated at 6 hours to assess contrast clearance. VAS pain scores were recorded immediately before the intervention and immediately after completion of the evacuation procedure. Functional outcomes were assessed at 6 months using the Quick Disabilities of the Arm, Shoulder, and Hand (Quick-DASH) questionnaire to evaluate mid-term upper extremity function. Radiographic confirmation was performed not only to document the presence of extravasation but also to assess the extent and compartmental distribution, as suggested in recent guidelines.

Statistical Analysis

All statistical analyses were performed using SPSS software (version 27.0; IBM Corp., Armonk, NY, USA). Continuous variables were expressed as median (interquartile range) or mean ± standard deviation, as appropriate. Due to the relatively small sample size, nonparametric statistical methods were preferred. Pre- and post-procedural VAS score comparisons were performed using the Wilcoxon signed-rank test. Comparisons between anatomical locations were conducted using the Kruskal–Wallis test. Correlations between extravasated volume and functional outcomes (Quick-DASH scores) were evaluated using Spearman's correlation coefficient. A p-value of <0.05 was considered statistically significant.

Figure 1: Step-by-step demonstration of the modified squeeze technique. **A)** Sterile preparation of the extravasated site, **B)** creation of puncture sites with a 20G needle, **C)** total of 15 punctures, **D)** peripheral-to-central squeezing maneuver, and **E)** successful evacuation of contrast.

Figure 2: Radiographs before and after contrast evacuation of the same patient. **A-B)** AP and lateral images before the procedure; **C)** immediate AP image after evacuation; **D-E)** AP and lateral images at 6th hour post-procedure.

Sample Size Consideration

Given the retrospective design and limited number of eligible cases, no formal a priori sample size calculation or power analysis was performed. Instead, all consecutive eligible patients presenting during the study period were included.

Declaration of Artificial Intelligence (AI) Use

The authors used an artificial intelligence–based language model (ChatGPT, OpenAI, San Francisco, CA, USA) solely to assist with language editing, grammar correction, and improvement of manuscript clarity. All scientific content, study design, data analysis, interpretation of results, and final decisions were performed exclusively by the authors. The authors take full responsibility for the accuracy and integrity of the work.

RESULTS

A total of 18 patients were included, with a mean age of 56.06 ± 17.24 years. Eleven patients (61%) were female, and seven (39%) were male. The most common site of contrast extravasation was the elbow (50.0%, n = 9), followed by the forearm (33.3%, n = 6) and hand (16.7%, n = 3). Thoracic CT was the most frequent examination associated with extravasation (44.4%, n = 8), followed by abdominal CT (38.9%, n = 7) and pelvic CT (16.7%, n = 3) (Table 1).

Radiologic assessment demonstrated radiographic clearance of extravasated contrast material in all included patients immediately following the procedure and at the 6-hour follow-up.

Pain levels improved markedly after the intervention. Mean VAS scores decreased significantly from 7.11 ± 1.23 pre-procedure to 1.44 ± 0.92 post-procedure according to the Wilcoxon signed-rank test ($p < 0.001$) (Table 2), indicating substantial pain relief.

Functional outcomes were excellent at 6 months. The mean extravasated volume was 97.22 mL, ranging from 70 mL to 130 mL. The mean Quick-DASH score was 2.02 ± 4.33, with a median of 0 (IQR 0–2.27), demonstrating near-complete recovery of upper extremity function in most patients (Table 2). Extravasated volumes were comparable across anatomical locations (hand: 93.3 ± 25.2 mL; forearm: 100.0 ± 21.0 mL; elbow: 96.7 ± 18.7 mL), with no statistically significant difference observed using the Kruskal–Wallis test ($p = 0.887$).

When outcomes were compared according to CT region (thorax, abdomen, pelvis) or extravasation site (elbow, forearm, hand), no statistically significant differences were observed in VAS improvement, Quick-DASH scores, or extravasated volume (all $p > 0.05$). A moderate positive correlation was observed between extravasated volume and

Quick-DASH score (Spearman's r = 0.421), although this did not reach statistical significance (p = 0.082) (Table 2).

No repeated evacuation procedure was required, and a single-session intervention was sufficient in all patients. No procedure-related complications, including infection, hematoma, cutaneous sensory disturbance, median nerve injury, vascular injury, or neurovascular compromise, were observed during follow-up.

DISCUSSION

The most important finding of this study is that the modified squeeze maneuver achieved radiologic clearance in all patients, produced marked pain relief, and resulted in near-normal upper extremity function at 6 months, without any procedure-related complications. Mean VAS scores decreased by more than five points, and the median Quick-DASH score was 0, indicating almost complete functional recovery. Together, these results demonstrate that the technique is not only effective but also safe and clinically meaningful in the acute management of contrast medium extravasation. These findings are particularly noteworthy given that current literature on contrast medium extravasation is largely based on small case series and lacks standardized, evidence-based interventional strategies (14). Moreover, existing guidelines predominantly favor conservative management, despite the absence of strong comparative data supporting this approach (15,16).

Table 1: Patient Demographics and Clinical Features

Feature	Value
Total Number of Patients	18
Age (Mean ± SD)	56.06 ± 17.24 years
Gender (Female/Male)	11 (61%) / 7 (39%)
Extravasation Site	Elbow: 9 (50%) Forearm: 6 (33.3%) Hand: 3 (16.7%)
Imaging Type	Thorax CT: 8 (44.4%) Abdomen CT: 7 (38.9%) Pelvis CT: 3 (16.7%)

The percutaneous squeeze maneuver was originally introduced by Tsai et al. in 2007 as a minimally invasive alternative to observation or surgical intervention (13). However, their description lacked procedural standardization, precise anatomical targeting, radiologic confirmation, and objective functional outcome assessment. Furthermore, needle placement was limited to the subcutaneous tissue without intentional fascial penetration, which may have limited effective evacuation in deeper extravasations. Similar minimally invasive techniques, including multiple incision and manual expression methods, have been described in the literature; however, these approaches remain heterogeneous and are often applied without standardized protocols or objective validation of treatment success (14,17). As a result, their reproducibility and clinical applicability remain limited.

Our modified approach was specifically designed to address these shortcomings. By introducing a predefined geometric puncture pattern, advancing needles to the fascial plane, and applying controlled peripheral-to-central compression, we aimed to maximize mechanical evacuation of contrast material. The predefined geometric puncture configuration was also intended to improve procedural reproducibility while minimizing uncontrolled tissue trauma in anatomically sensitive regions such as the antecubital fossa. In contrast to the original report, we incorporated radiographic validation and functional follow-up to objectively quantify treatment success. Radiologic assessment has been increasingly emphasized in recent literature as a valuable tool for confirming the extent of extravasation and evaluating treatment response, particularly in moderate to severe cases (15,18). We believe that the addition of fascial-level drainage, standardized application, and measurable outcomes represents a meaningful evolution of the maneuver described by Tsai et al. (13). The relatively clear appearance of post-procedural radiographs may reflect the immediate and effective evacuation of contrast material; however, subtle soft tissue changes, such as edema or minimal residual contrast, may not be fully appreciated on plain radiographs.

The need for such an approach is increasingly relevant. Although most cases of CME are managed conservatively,

Table 2: Clinical Outcomes and Statistical Summary

Parameter	Result
VAS Score Change	5.67 ± 0.84 (p <0.001)*
Quick-DASH Score (Sixth months)	2.02 ± 4.33
Extravasated Volume (Mean)	97.22 (70-130) mL
Correlation: Volume vs Quick-DASH	r = 0.421, p = 0.082 (not significant)
Complications	None (No infection, nerve damage, hematoma, etc.)

* Wilcoxon signed-rank test.

the available evidence supporting this approach remains limited and is largely based on observational data (14). With the widespread use of automatic pressure injectors, the incidence of CME has risen (2,19,20) and contrast may disseminate more deeply along fascial planes (20). Importantly, several reports have demonstrated that delayed or insufficient intervention may lead to adverse outcomes, including tissue necrosis or compartment syndrome, even in cases that initially appear clinically mild (21). Despite this variability, there is still no universally accepted treatment algorithm, and management remains largely empirical. Our findings suggest that the modified squeeze technique offers a practical intermediate strategy—more proactive than passive observation yet considerably less invasive than surgery.

Concern regarding ACS often drives aggressive management (20). Although direct intracompartmental pressure measurement is considered the most definitive diagnostic method, clinical assessment remains the most commonly applied approach in daily practice (9). In our cohort, careful pre- and post-procedural monitoring revealed no neurovascular compromise or compartment syndrome. Importantly, severe complications have been reported even in small-volume extravasations (22,23), supporting early mechanical evacuation rather than exclusive reliance on observation.

Current guidelines, including those from the European Society of Urogenital Radiology, predominantly recommend conservative measures such as limb elevation, cold compresses, and observation (11,12,20). However, comparative evidence between conservative and interventional strategies is limited. More invasive methods such as saline irrigation or liposuction may be effective but require anesthesia and specialized equipment, limiting their feasibility in emergency settings (24,25). In contrast, the modified squeeze technique can be performed rapidly at the bedside using readily available instruments, without anesthesia or operative infrastructure. Its simplicity, low cost, reproducibility, and absence of complications make it an attractive bridge between conservative care and surgical intervention.

This study has several limitations. First, the sample size was relatively small, and no control group was included; therefore, direct comparisons with conservative management or other interventional techniques cannot be made. Second, all procedures were performed at a single center, which may limit the generalizability of the findings to different clinical settings. Third, radiologic clearance was assessed qualitatively based on plain radiographic evaluation rather than through quantitative volumetric analysis, which may limit the precision of contrast evacuation measurement. In addition, the relatively small sample size limited the statistical power of the study and restricted the use of more robust comparative analyses. Finally, all patients were treated in the acute phase of CME, and the effectiveness of this technique in delayed presentations remains uncertain. Despite these limitations, the consistent radiologic improvement, significant pain reduction, and favorable mid-term functional outcomes provide a rationale for further validation in larger prospective or comparative studies.

Conclusion

The modified percutaneous squeeze maneuver achieved radiologic clearance, substantial pain reduction, and excellent mid-term functional recovery without complications in this series of patients with contrast medium extravasation. By combining fascial-level drainage with procedural standardization and objective outcome validation, this technique offers a practical and minimally invasive alternative to both passive observation and operative intervention. Although further multicenter and controlled studies are needed, the present findings support its potential role as a safe and effective strategy in the acute management of contrast extravasation injuries.

Author Contributions

The authors confirm their contributions to the paper as follows: Study conception and design: **Ozan Altun, Uygar Daşar;** data collection: **Ozan Altun, Yılmaz Ergişi, Erdi Özdemir;** analysis and interpretation of results: **Anıl Tarık Saygılı, Erdi Özdemir, Uygar Daşar;** draft manuscript preparation: **Ozan Altun, Süleyman Albayrak, Anıl Tarık Saygılı.** The authors reviewed the results and approved the final version of the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest related to this study.

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Ethical Approval

This study was approved by the Karabük University Non-Interventional Clinical Research Ethics Committee (Approval No: 2023/1485). Written informed consent was obtained from all participants.

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