Flap failure is often related to vascular complications during the perioperative period. Microvascular thrombosis is often attributable to irreversible damage to the microcirculation, and may have ultimately been responsible for flap failure. A number of authors have reported that vascular thrombosis remains the primary reason for flap loss and venous thrombosis was more than twice as common as arterial thrombosis. Several cause of venous thrombosis are known including external compression by a hematoma or edema, mechanical stress at the anastomotic junction, torsion or kinking of a flap pedicle, technical errors, hypercoagulable states.

During the perioperative period, intravascular volume depletion can also promote venous thrombosis. Some patients who underwent long time reconstructive free flap procedure may suffer pulmonary edema caused by fluid overload, requiring perioperative medical intervention including use of diuretic agents such as furosemide. In some patients who undergo free flap reconstruction may suffer pulmonary edema, requiring postoperative medical intervention including use of diuretic agents, such as furosemide. However, the effect of diuretic agents on a free flap remains unclear. We present a case of flap loss due to venous thrombosis following intravenous infusion of furosemide in a 36-year-old patient. The patient suffered from severe dyspnea and acute pulmonary edema caused by fluid overload during the perioperative period. Furosemide was administered intravenously for relieving dyspnea. After 4 hours, the flap showed signs of venous congestion. Surgical exploration revealed a venous thrombosis of the vascular pedicle with complete luminal occlusion. We would like to suggest that use of furosemide in patients underwent reconstruction with free flaps must be limited only to cases with evidence of acute respiratory failure. Even in these cases, intensive flap monitoring and preparation for early intervention on venous thrombosis will be required.

Key Words: Venous thrombosis, Free flaps, Furosemide
patients using diuretic agents, the consequent reduction in intravascular volume can lead to decrease in blood flow and increase in blood viscosity. As viscosity is further increased, venous thrombosis leading to venous obstruction may occur more frequently.

However, there were no studies that the influence of diuretics, particularly furosemide, on venous thrombosis in free flap procedure. We report a case of venous thrombosis occurred after intravenous administration of furosemide in a 36-year-old man had soft tissue defect on the dorsum of hand using anterolateral thigh perforator flap.

**CASE REPORT**

A 36-year-old man with recurrent osteomyelitis on left forearm underwent a radical debridement of the infected bone and soft tissue followed by immediate forearm reconstruction using anterolateral thigh perforator free flap. The donor artery and vein were anastomosed to the ulna artery and vein. The patient was a non-smoker without comorbidity. His preoperative laboratory parameters, including a coagulation profile, were all within normal limits.

Postoperative course was uneventful and flap circulation was maintained in good state. Approximately 4 hours following surgery, venous congestion occurred at the edge of the flap in presence of an underlying hematoma (Fig. 1). Several sutures were stitched out and hematoma was removed. There was no evidence of vascular compromise.

With the temporary venous congestion resolved completely on postoperative day 3. On day 4 after free flap transfer, the patient suffered from severe dyspnea, and an oxygen saturation decreased less than 90%. The patient was transferred to the surgical intensive unit for intensive monitoring. The x-ray radiography was demonstrated evidence of acute pulmonary edema (Fig. 2). With con-
sultation of department of internal medicine, 20 mg furosemide (Lasix®; Handok Pharmaceuticals Co., Seoul, Korea), were administered intravenously. Total 3 hours urine output after furosemide injection was 1,100 mL.

Within 4 hours, the skin island clinically showed signs of venous congestion (Fig. 3). Immediate revision of the pedicle was performed revealing a long-segment thrombosis of the venous pedicle (Fig. 4). A thrombectomy of the venous pedicle with revision of the anastomosis and vein graft was done. Despite these efforts, thrombosis of the vein recurred and resulted in total loss of the flap. Finally, the defect was successfully reconstructed with distant groin flap.

DISCUSSION

The perioperative period is a time of increased risk of complications in patients with free flap reconstruction, with the respiratory system frequently affected. Older patients with medical comorbidities and a long duration (>4 hours) of anesthesia have also been shown to be risk factors for pulmonary complication in a flap surgery.

Furosemide is a diuretic which is indicated in patients for the treatment of edema associated with congestive heart failure, cirrhosis of the liver and renal disease, including the nephrotic syndrome. It directly inhibits the reabsorption of sodium and chloride from the loop of Henle and distal renal tubule. By this action, water reabsorption from the collecting duct is impaired, and it produces significant natriuresis during the 6-hour period following furosemide administration.
drug administration. To our knowledge, there is no current literature reviewing the influence of diuretics on free flap surgery. Manley et al.\(^7\), in a case of free flap used for post-pneumonectomy space empyema requiring high-dose diuretics, showed no flap compromise in this setting. Montero et al.\(^8\) also used furosemide in patients to manage rhabdomyolysis after prolonged free flap surgery. The authors reported no complication directly related to furosemide and thrombotic events did not happen.

In our case, the venous thrombosis occurred immediately after the administration of the agent, thus we speculated that there might be correlation between the use of furosemide and free flap thrombosis. The patient might be at an especially high risk for venous thrombosis as a result of a combination of previous vessel compression by a hematoma and additional intravascular volume depletion. In other words, the presence of a hematoma may induces a intravascular prothrombotic state caused by mechanical trauma of intima and furosemide induced venous hyperviscosity may trigger venous thrombosis.

The fluid management of patients undergoing free flap reconstruction is particularly important to maintain adequate blood flow in the flap. The administration of excessive amounts of fluid to these patients can lead to adverse outcomes, such as pulmonary edema and congestion, and this is especially the case in elderly patients with cardiac or renal impairment. Several diuretics are available for pulmonary edema including loop diuretics, thiazides and potassium sparing diuretics. Loop diuretics are used as the first line of therapy to treat pulmonary edema with fluid overload, but we recommend use furosemide after free flaps only in cases with evidence of acute respiratory and heart failure. The others have different mechanisms of action, but all diuretics can cause volume depletion with venous hyperviscosity. These risks must be weighed against the risk of venous thrombosis due to diuretics administration in the immediate postoperative period. If massive diuresis occur following diuretics administration, flaps should be monitored carefully and frequently. As venous thrombosis is the main reason for flap loss, urgent exploration should be performed in all suspected cases. Further studies should be performed to verify influence of furosemide on vascular thrombosis after free flaps.

**CONFLICTS OF INTEREST**

The authors have nothing to disclose.

**REFERENCES**

1. Hidalgo DA, Disa JJ, Cordeiro PG, Hu QY. A review of 716 consecutive free flaps for oncologic surgical defects: refinement in donor-site selection and technique. Plast Reconstr Surg. 1998;102:722-32; discussion 733-4.
2. Kroll SS, Schusterman MA, Reece GP, et al. Timing of pedicle thrombosis and flap loss after free-tissue transfer. Plast Reconstr Surg. 1996;98:1230-3.
3. Yu P, Chang DW, Miller MJ, Reece G, Robb GL. Analysis of 49 cases of flap compromise in 1310 free flaps for head and neck reconstruction. Head Neck. 2009;31:45-51.
4. Ozbek MR, Deune EG, Cooley BC, Khouri RK. Experimental reproduction of free flap errors: a new model of thrombosis. Ann Plast Surg. 1994;32:474-7.
5. Khouri RK, Cooley BC, Kunselman AR, et al. A prospective study of microvascular free-flap surgery and outcome. Plast Reconstr Surg. 1998;102:711-21.
6. Brooks-Brunn JA. Predictors of postoperative pulmonary complications following abdominal surgery. Chest. 1997;111:564-71.
7. Manley K, Gelvez S, Meldon CJ, Levai I, Malata CM, Coonar AS. Free deep inferior epigastric perforator flap used for management of post-pneumonectomy space empyema. Ann Thorac Surg. 2013;95:e83-5.
8. Montero F, Gimenez I, Ferrer A, Baena M, Aguilar J. Rhabdomyolysis after a prolonged surgical procedure. Eur J Anaesthesiol. 2008;25(Suppl 44):232.
유리 피판술을 시행한 환자에서 Furosemide 정맥 주사 후 발생한 피판 정맥 내 혈전: 증례 보고

정수영 · 정성호 · 동은상 · 한승규 · 김우경
고려대학교 의과대학 성형외과학교실

유리 피판술을 시행 받은 환자 중 수술 후에 급성 폐부종이 발생하는 경우가 있는데, 이는 저산소혈증을 동반하므로 즉각적인 치료를 필요로 하게 된다. 폐부종 치료를 위해서는 이뇨제 사용이 필요하나, 이뇨제의 사용이 유리 피판에 어떠한 영향을 미치는지에 대해서는 아직 명확하게 밝혀지지 않았다. 저자들은 유리 피판을 시행한 환자에서 Furosemide를 정맥 내로 주입한 후 피판 정맥 내 혈전이 발생한 증례를 경험하였다. 수액 과부하로 인한 폐부종이 발생하면 과도하게 투여된 수액을 제거하기 위해 이뇨제를 사용하여야 하며, 이 경우 유리피판의 혈행 부전이 발생할 수 있음을 인지하여야 한다.

색인단어: 정맥 혈전, 유리 피판술, 고리관 이뇨제

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