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The effect of increased hip flexion using stirrups on lower-extremity venous flow: a prospective observational study

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Abstract

BACKGROUND: Patient positioning during surgeries for colorectal cancer may represent an unrecognized risk factor for deep venous thrombosis.

METHODS: Twelve healthy control patients were positioned supine with knee flexion at 90°. Duplex ultrasound examined common femoral vein (CFV) and proximal femoral vein diameter, peak systolic velocity, and volume flow with hip flexion at 0°, 30°, 60°, and 90°. Data were analyzed using the paired t test.

RESULTS: In the CFV, hip flexion to 90° was associated with a significant increase in mean volume flow when compared with hip flexion at 0° (.59 vs .36 L/min; $P = .05$) and 30° (.59 vs .35 L/min; $P = .038$). In both the CFV and proximal femoral vein, increased hip flexion was associated with significantly reduced vessel diameter and increased peak systolic velocity.

CONCLUSIONS: Intraoperative positioning of the lower extremities represents a modifiable risk factor for deep venous thrombosis. When stirrups are used, hip flexion of 90° maximizes venous drainage from the legs.

Venous thromboembolism (VTE) is a disorder with short-term mortality and long-term morbidity.[1,2] Risk-adjusted models have shown that VTE is a significant predictor of death in colorectal cancer patients. Fifty-two percent of colorectal cancer patients who develop VTE will die within 2 years, compared with 35% of those who do not develop VTE.[3] Patients who present for colorectal cancer surgery have inherent risk factors for VTE including age, obesity, malignancy-associated hypercoagulability, and need for surgery under general anesthesia.[4–6] These inherent risk factors often cannot be modified before surgery.

Venous stasis is a recognized risk factor for deep venous thrombosis (DVT). Several intraoperative and postoperative factors are known to affect lower-extremity venous flow and are potentially modifiable. For example, induction of pneumoperitoneum, as commonly performed for laparoscopic

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surgery, significantly increases intra-abdominal pressure. This results in lower-extremity venous stasis, venous dilation, and intimal microtears in the vein wall, which are all recognized DVT risk factors.[7–11] Similarly, postoperative compression garments and abdominal wall binders are known to impede lower-extremity venous drainage.[12]

Patient positioning is a potential risk factor for DVT that can be modified easily. The American College of Chest Physicians VTE prophylaxis guidelines note that the reverse Trendelenburg position is associated with lower-extremity venous stasis.[6] VTE prophylaxis guidelines in plastic surgery[13,14] recommend knee flexion at 5° to maximize flow through the popliteal vein. In addition, studies in total hip arthroplasty patients show that intraoperative manipulation of the lower extremity, including flexion, adduction, and internal rotation at the hip, can kink and occlude the femoral vein.[15–17]

Intraoperative positioning using stirrups, as is performed commonly for colorectal cancer surgery, routinely flexes and abducts the hip, which could impede or obstruct lower-extremity venous drainage. We hypothesized the following: (1) increased hip flexion may narrow or occlude the femoral vein and, as a result, (2) hip flexion may impede lower-extremity venous drainage, causing venous stasis. Thus, surgical positioning using stirrups may represent an unrecognized, easily modifiable risk factor for lower-extremity DVT after colorectal cancer surgery. To examine our hypotheses, we performed a prospective, observational study to examine the effect of increasing hip flexion on femoral vein diameter, peak systolic velocity, and volume flow in a group of healthy control patients.

Materials and Methods

This study was approved by the University of Michigan Institutional Review Board. All patients signed informed consent before participation.

Healthy control patients with minor hand lacerations, fractures, or infections were recruited from the University of Michigan plastic surgery clinic. Study inclusion criteria included male sex, age 20- to 50 years, and the ability to provide informed consent. Obesity has been shown to significantly alter common femoral vein (CFV) diameter and peak systolic velocity[18] in addition to making studies technically difficult. Thus, patients with a body mass index of 35 or greater were excluded. Patients who were scheduled for surgery under general anesthesia, or who had general anesthesia within the past 2 months, were excluded. All patients received a physical examination to rule out clinical evidence of venous insufficiency, such as lower-extremity edema, varicosities, or hemosiderin deposits. We also excluded any patient with a history of lower-extremity varicosities, edema, lymphedema, amputation, significant trauma, or prior surgical intervention that could impede lower-extremity venous drainage. Finally, patients with prior major abdominal surgery or a personal or family history of VTE were excluded.

Table 1 Summary of measurements performed in each position

	Hip flexion	Hip abduction	Knee flexion	Measurements
Baseline	0°	20°	0°	Bilateral lower-extremity duplex ultrasound
Baseline	0°	20°	90°	Bilateral CFV and PFV diameter, peak systolic velocity, volume flow
Variant 1	30°	20°	90°	Bilateral CFV and PFV diameter, peak systolic velocity, volume flow
Variant 2	60°	20°	90°	Bilateral CFV and PFV diameter, peak systolic velocity, volume flow
Variant 3	90°	20°	90°	Bilateral CFV and PFV diameter, peak systolic velocity, volume flow

Duplex ultrasound measurements for all enrolled patients were performed by the same 2 registered vascular technologists (S.M.S. and S.L.B.) using the Antares Ultrasound System (Siemens, Mountain View, CA). All studies were interpreted by a registered vascular technologist and a board-certified vascular surgeon. Positions in which measurements were taken are summarized in Table 1. A pictorial representation of these positions is shown in Fig. 1.

Patients were laid supine on the operating room table for baseline analyses. A supine lower-extremity duplex ultrasound showed absence of DVT before the study protocol was initiated. The legs then were placed in Yellofin stirrups (Allen Medical Systems, Acton, MA). Measurements for the CFV were obtained immediately distal to the inguinal ligament in all patients. The proximal femoral vein (PFV) was identified as just distal to the bifurcation of the CFV into the femoral and profunda veins and measurements were taken within 1 cm of this location.

Baseline analysis of the patient's CFV and PFV cross-sectional diameter, peak systolic velocity, and volume flow were obtained with the knee in 90° of flexion and the hip abducted to 20°. The hip then was flexed to 30° while knee flexion and hip abduction remained unchanged. CFV and PFV measurements as described earlier then were repeated. This sequence was repeated with the hip in 60° and 90° of flexion while keeping knee flexion and hip abduction stable. After each change in hip flexion, the patient was left in position for 5 minutes to allow for equilibration before additional measurements were taken. The range of hip flex-