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Gluteal Compartment Syndrome: A Systematic Review of the Literature

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Abstract

Gluteal compartment syndrome (GCS) is a rare surgical emergency where ischemic changes occur to the gluteal muscles from an increase in compartment pressure. While the condition is rare, it is associated with significant risk of high morbidity and mortality. The purpose of this systematic review of the literature was to compile and review the current evidence of the causes, treatments, and outcomes of GCS.

This systematic review was performed at a level-one trauma center and was an institutional review board-exempt study. EmBase, Ovid, and PubMed databases were searched for case reports and series of gluteal compartment syndrome. The publications were reviewed and analyzed to identify the causes and conditions that lead to GCS.

Our review identified two major mechanisms leading to GCS: iatrogenic and non-iatrogenic. Iatrogenic mechanisms included prolonged immobilization due to decreased sensation following surgery with spinal anesthesia, intraoperative hypoperfusion during surgical procedures, intraoperative positioning, bone marrow biopsy complications, prolonged immobilization due to intubation postoperatively, gluteal morphine injection, and statin-induced myositis. Non-iatrogenic mechanisms included prolonged immobilization secondary to substance abuse, trauma, and over-exertion.

We reported on the clinical outcomes associated with regard to mechanism and treatment, discussed different types of fasciotomy incisions used in the treatment of GCS, delineated general recommendations for managing GCS, and identified areas for further research.

Introduction

Compartment syndrome is a rare pathologic process where pressure increases between fascial planes, leading to poor perfusion and ischemia. If it is not promptly addressed, prolonged ischemia will result in neurovascular damage, rhabdomyolysis, and tissue necrosis. During muscle breakdown and death, myoglobin and other intracellular substances enter the circulation leading to complications such as life-threatening arrhythmias and acute renal failure.

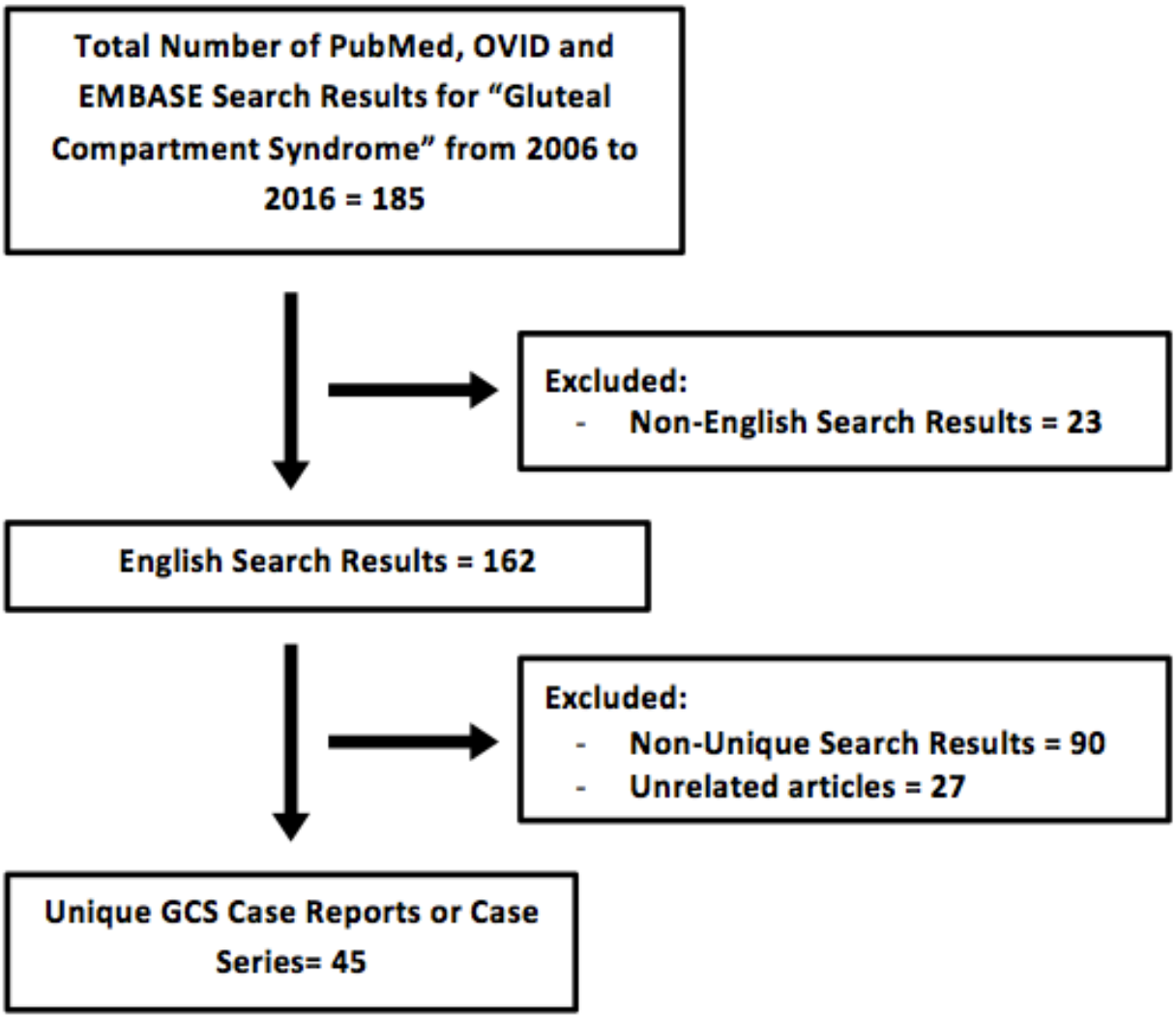
The most common locations for compartment syndrome to occur are the upper or lower extremities, mainly as a result of trauma. However, it can occur in any area where a muscle compartment exists. The gluteal musculature, comprised of the gluteus maximus, medius, and minimus, is at risk for gluteal compartment syndrome (GCS) in the correct clinical setting. A missed diagnosis can lead to permanent disability, but due to the rarity of the disorder the literature is primarily composed of case reports. The focus of this systematic review is to comprehensively evaluate the literature in order to help clinicians become more aware of the presentation of GCS and improve outcomes for these patients.

Methods

The systematic review was performed as an institutional review-board exempt study at a level-one trauma center. Two investigators independently performed electronic searches of Embase,

Ovid, and PubMed utilizing the phrase “gluteal compartment syndrome”. Results were restricted to papers published within the last 10 years. The collective search results yielded 72 publications in Embase, 54 in Ovid, and 59 in PubMed for a total of 185 papers. The searches were completed on January 24, 2017. Only case reports and case series written in English describing one or more patients diagnosed with gluteal compartment syndrome were included. Papers not meeting these criteria were excluded. Three systematic reviews were excluded as their publication references were contained within our literature search. Forty-five papers met the inclusion criteria (see Figure 1). The reports were analyzed for patient demographics and information regarding the mechanism of injury, diagnosis, treatment, mortality, and clinical outcome (see Table 2).

Figure 1.



Results

Patient Demographics:

Analysis of the 45 papers described a total of 49 cases. 43 were males, 6 were females. The average age was 47.65 years (standard deviation = 15.6) (see Table 1).

Table 1.

Author	Age	Gender	Ethnicity	Obese	BMI	Co-morbidities
Adrish	42	Male	n/a	n/a	n/a	heroin abuse, previous gunshot wound to the head, previous neuropathy secondary to heroin use
Berumen-Nafarrate	51	Male	n/a	n/a	n/a	non-Hodgkin lymphoma
Castro-Garcia	49	Male	Hispanic	n/a	n/a	n/a
Chew	64	Male	Chinese	n/a	n/a	smoker, hypertension, abdominal aortic aneurysm
Diaz Dilernia	70	Male	n/a	n/a	n/a	n/a
Gee	32	Male	n/a	n/a	n/a	n/a
Greco	52	Female	n/a	n/a	n/a	Hodgkin lymphoma
Hafez	24	Male	African American	n/a	n/a	n/a
	44	Female	n/a	n/a	n/a	alcoholic liver disease
Hau	72	Male	n/a	n/a	n/a	former smoker, type 2 diabetes mellitus, hypertension, hyperlipidemia, and right hemi-colectomy for colonic cancer
Hayden	49	Male	n/a	n/a	n/a	n/a
Heyn	52	Male	n/a	n/a	n/a	prostate carcinoma
Horer	47	Male	n/a	n/a	n/a	n/a
Iizuka	20	Male	n/a	Yes	38.8	alcohol abuse
Kao	36	Female	n/a	n/a	n/a	n/a
Keene	61	Male	n/a	Yes	40.2	obesity, diabetes mellitus, prostate cancer
Kong	50	Male	n/a	No	29	heroin abuse, diabetes, tuberculosis, and hepatitis C virus infection
Kumar	46	Female	n/a	Yes	n/a	obesity
	71	Male	n/a	No	n/a	overweight
	55	Male	n/a	No	n/a	overweight
	72	Male	n/a	n/a	n/a	n/a
Lawrence	50	Male	n/a	n/a	n/a	heroin abuse
Lederman	24	Male	n/a	n/a	n/a	heroin abuse
Liu HL	74	Male	n/a	n/a	n/a	alcohol abuse
Liu CY	27	Male	n/a	n/a	n/a	drug abuse
MacKay	21	Male	n/a	n/a	n/a	n/a
Mar	n/a	Male	n/a	n/a	n/a	n/a

Matta	56	Male	n/a	No	29	n/a
McGoldrick	53	Female	n/a	n/a	n/a	iron deficiency anemia, thrombocytopenia, hypertension, diabetes mellitus, metallic mitral & aortic valve replacements
Mitsiokapa	47	Male	n/a	n/a	n/a	drug abuse
Mustafa	50	Male	Caucasian	n/a	n/a	chronic obstructive pulmonary disease
Narayan	25	Male	Caucasian	n/a	n/a	n/a
Oates	69	Male	n/a	Yes	46	transitional cell carcinoma bladder, stage 3B renal disease, obstructive sleep apnea, hypertension, lumbar disc herniation
O'Leary	58	Male	n/a	Yes	41	n/a
Osteen	52	Male	n/a	Yes	n/a	hypertension, hyperlipidemia
Panagioto-poulos	38	Male	Caucasian	n/a	n/a	chronic intravenous drug abuse, hepatitis C virus infection
Pereira	52	Male	n/a	Yes	69.9	n/a
Polacek	65	Male	n/a	Yes	38	spinal stenosis, hypertension, diabetes mellitus, diabetic retinopathy, diabetic neuropathy, diabetic nephropathy with stage 3 renal disease
Rudolph	65	Male	n/a	Yes	39.1	hypertension, diabetes mellitus, diabetic retinopathy, diabetic nephropathy, diabetic polyneuropathy, hypercholesterolemia, degenerative lumbar stenosis
Shaikh	40	Male	n/a	n/a	n/a	n/a
Smith	61	Male	n/a	n/a	n/a	n/a
Songur	21	Male	n/a	n/a	n/a	n/a
Spratt	52	Male	n/a	n/a	n/a	n/a
Sullivan	55	Male	n/a	n/a	n/a	n/a
Tasch	23	Male	African American	n/a	n/a	history of drug abuse (heroin, cocaine)
Taylor	28	Male	n/a	n/a	n/a	n/a
Viviani	59	Male	n/a	Yes	30.9	abdominal aortic aneurysm, hypertension, dyslipidemia, mild chronic renal failure
Woon	36	Male	Caucasian	n/a	n/a	acute disseminated encephalomyelitis at age 24
Young	30	Female	n/a	No	19.3	n/a

Mechanism of injury:

All 49 case reports included the mechanism of injury that led to GCS**.** The reported mechanisms were categorized as iatrogenic and non-iatrogenic.

Iatrogenic causes accounted for 44.89% (22/49) of cases. They included prolonged immobilization due to decreased sensation following surgery with spinal anesthesia (7 cases) [20,26,47,32], intraoperative hypoperfusion during surgical procedures (4 cases) [4,10,37,39], intraoperative positioning (4 cases) [13,18,27,36], bone marrow biopsy complication (4 cases) [2,8,28,44], prolonged immobilization due to intubation postoperatively (1 case) [33], gluteal morphine injection (1 case) [14], and statin-induced myositis (1 case) [34].

Non-Iatrogenic causes included prolonged immobilization secondary to substance abuse, trauma, and over-exertion.

Prolonged immobilization secondary to substance abuse accounted for 26.53% (13/49) of cases [1,15,17,19,21,22,23,24,29,31,35,45,49]. Of those 13 cases, 46.15% (6 cases) [1,15,17,21,31,49] were found down and subsequently brought in for medical attention. Substances that lead to intoxication in these cases included ethanol, opiates, schizophrenic medication, and cocaine.

Trauma accounted for another 26.53% (13/49) of cases. Types of trauma leading to GCS included falls from a substantial height (2 cases) [3,41], fall from standing height (2 cases) [9,30], motor vehicle accident (6 cases) [5,7,9,11,43,46], crush injuries (2 cases) [40,42], and gunshot wound (1 case) [25].

Over-exertion led to 1 case (2.04% of cases) [48] of gluteal compartment syndrome in a bodybuilder, which was subsequently complicated by a superimposed infection.

Obesity was correlated with the development of GCS. Of the 49 cases of GCS, 10 patients were considered obese and 6 were not considered obese. Of the 10 obese patients, the average BMI was 42.43 and of the 6 not obese patients, the average BMI was 26.88. The standard deviation for BMI within those reported was 12.88. The remaining patients had a normal BMI or it was unreported in the paper. Additionally, one patient with iatrogenic GCS due to a bone marrow biopsy was previously anticoagulated with warfarin due to other medical conditions [28].

Diagnosis and Treatment:

Diagnosis of GCS in the case reports was made primarily by clinical exam findings such as firmness, swelling of the buttock and/or thigh, erythema and bruising of the buttock and/or thigh, blister formation over the buttock, tenderness to palpation of the buttock/thigh, decreased motor strength, decreased or absent lower extremity deep tendon reflexes, and hypoesthesia to pinprick sensation in the lower extremity.

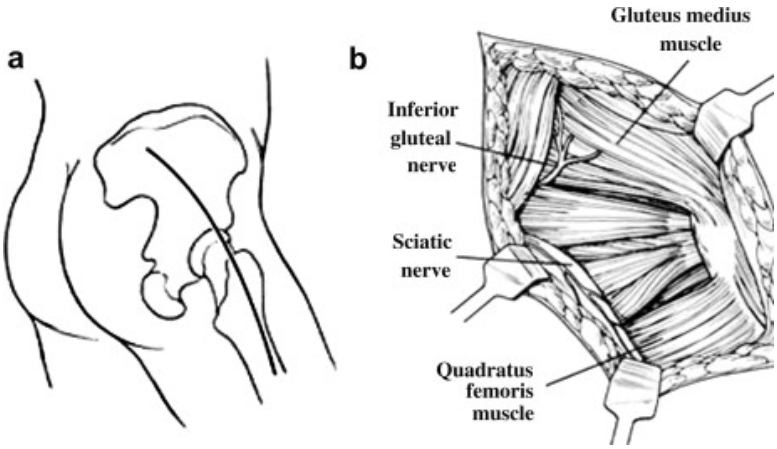
In addition, 36.73% (18/49) [2,3,4,5,10,13,14,15,18,24,25,26,27,32,36,45,47,48] of cases reported measuring intracompartmental pressures during the patient assessment. Of those 18 cases, 16 reported the exact pressure values (see Table 1). The average pressure was measured within any section of the gluteal compartment was 55.08 mmHg (standard deviation = 24.97 mmHg).

The majority of GCS was treated with fasciotomy alone in 73.47% (36/49) of cases [1,2,3,4,5,9, 10,13,15,16,18,19,20,21,22,224,25,27,30,31,32,33,34,35,36,37,38,39,40,41,45,46,47,48].

However, 8.16% (4/49) of cases were treated with fasciotomy and angioembolization combined [7,11,42,43]. All 4 of the cases that used both were in patients with trauma and subsequent hemorrhage as a mechanism, 3 of which were bicyclists struck by a motor vehicle [7,11,43] and bales of hay crushed the fourth patient [42]. Angioembolization alone was used in 6.12% (3/49) of cases [8,14,44]. All angioembolization treatment cases were iatrogenic which resulted in bleeding into the gluteal compartment, one from a morphine injection to the gluteus and two from a bone marrow biopsy. The other 12.24% (6/49) of cases were treated non-operatively [17,23,26,28,29,49].

For the cases that were treated operatively, 55% (22/40) of cases described their surgical technique. Of the surgical techniques used, 5 cases described the Kocher-Langenbach approach (see Figure 2. [16]) [18,31,43,46,48], 4 described a posterior approach [15,21,37,41], 3 described a question-mark approach [3,27,40], 3 described a curvilinear approach [4,24,47], 2 described a posterolateral approach [2,10], 2 lateral longitudinal [7,13], 1 mid-axial [11], 1 described the exact anatomical locations the incision extended through [19], and 1 reported decompression of all three compartments through the thigh [5].

Figure 2.



Mortality:

Of the 49 cases within the 45 case reports, only 1 patient died as a result of GCS complications [13]. The patient had multi-system organ failure due to GCS following a lung wedge resection with prolonged intubation postoperatively.

Clinical Outcomes:

In terms of clinical outcomes, 48.98% (24/49) of patients made a full recovery with no significant motor or sensory impairment, however the amount of time it took to achieve full recovery varied from a few days to 1 year [2,3,8,9,10,13,15,18,19,20,25,26,27,30,32,34,36,37, 41,42,43,48]. The extent of physical therapy varied between patients as well.

Motor dysfunction, sensory impairment, neuropathy, and pain were the four main types of permanent sequelae reported. Motor dysfunction was noted in 44.90% (22/49) of patients. These patients experienced marked muscle weakness (6 cases) [1,5,7,14,45,46], gait abnormalities (4 cases) [4,9,20,21], foot drop (7 cases) [17,22,23,28,31,40,49], and mobility impairment (5 cases)

24,35,39,44,47]. Sensory impairment was seen in 4.08% (2/49) of patients [7,35], neuropathy in 12.24% (6/49) [5,14,23,24,29,35], and pain in 10.20% (5/49) of cases [14,22,35,39,45]. A combination of motor dysfunction, sensory impairment, neuropathy, and pain was seen in 18.37% (9/49) cases [5,7,14,22,23,24,35,39,45].

Of the iatrogenic causes, 63.63% (14/22) made a full recovery without sequelae [2,8,10,13,18,20, 26,27,32,34,36,37]. Of the remaining 8 cases, 1 patient died as a result of GCS complications [33]. The other 7 suffered motor impairment (31.81%, 7/22) [4,14,20,28,39,44,47], sensory impairment (4.55%, 1/22) [14], and pain (9.09%, 2/22) [14,39]. A combination of sequelae was seen in 9.09% (2/22) of iatrogenic cases [14,39].

Of the prolonged immobilization secondary to substance abuse was associated with a higher percentage of permanent impairment. Only 15.38% (2/13) of cases had no sequelae or made a full recovery [15,19]. Motor impairment was seen in 76.92% (10/13) of cases [1,17,21,22,23,24,31,35,45,49], sensory impairment in 7.69% (1/13) of cases [45], neuropathy in 23.07% (3/13) of cases [23,24,29], and pain in 15.38% (2/13) of cases [22,35]. A combination of sequelae was seen in 38.46% (5/13) of prolonged immobilization cases [22,23,24,35,45].

Of the non-iatrogenic trauma-induced mechanisms, 58.33% (7/12) had no sequelae or a full-recovery [3,9,25,30,41,42,43]. Motor impairment was seen in 41.66% (5/12) of cases [5,7,9,40,46], sensory impairment in 8.33% (1/12) of cases [7], and neuropathy in 16.66% (2/12) of cases [5,11]. A combination of sequelae was seen in 16.66% (2/12) of trauma-induced cases [5,7].

The GCS case due to over-exertion made a full recovery with no permanent sequelae [48].

In regards to the relationship between treatment and clinical outcome, non-operatively managed patients had a higher rate of complications. Only 16.67% (1/6) made a full-recovery [26]. Motor complications were seen in 66.67% (4/6) of cases [17,23,28,49] and neuropathy in 33.33% (2/6) of cases [23,29]. A combination of sequelae was seen in 16.67% (1/6) of non-operatively managed cases [23]. Of the 6 cases that were managed non-operatively, 5 cases did not report a compartment pressure measurement [17,23,28,29,49]. The remaining case said a pressure measurement was performed, but the exact value was not reported [26].

Table 2.

Author	No. of Patients	Mechanism	Pressure Measurements	Outcomes
Adrish	1	Non-iatrogenic: prolonged immobility secondary to substance use, patient found down	No	Persistent lower extremity weakness
Berumen-Nafarrate	1	Iatrogenic: OR-induced, hemorrhage secondary to posterior iliac crest bone marrow aspiration	Yes, 54	No sequela, discharged home on post-operative day #6
Castro-	1	Non-iatrogenic: trauma	Yes, Left - 60	No sequela, discharged

Garcia		secondary to a fall 10 feet from a ladder	mmHg, Right - 50 mmHg	home on post-operative day #7
Chew	1	Iatrogenic: OR-induced, secondary to hypoperfusion from intra-operative clamping	Yes, Left - 115 mmHg	Complete excision of the gluteus muscles, permanent gait impairment
Diaz Dilernia	1	Non-iatrogenic: Trauma, pelvic ring injury, crush injury due to motor vehicle accident (MVA)	Yes, 46 mmHg	Sciatic nerve palsy, Decreased motor strength in the anterior tibialis, musculus peroneus longus, and musculus peroneus brevis
Gee	1	Non-iatrogenic: Trauma, right superior gluteal artery bleed due to MVA	No	Marked muscle weakness in the right lower leg and severe sensory loss in the L5/S1 distribution
Greco	1	Iatrogenic: OR-induced, hemorrhage secondary to bone marrow harvesting	No	No sequela, discharged to home
Hafez	2	Non-iatrogenic: Trauma, motor vehicle accident	No	Resolution of motor and sensory problems
		Non-iatrogenic: Prolonged immobility, secondary to head trauma from falling	No	Gait impairment, Loss of right medius, minimus, and part of the gluteus maximus
Hau	1	Iatrogenic: OR-induced, secondary to intra-operative hypoperfusion due to anatomic variation during fenestrated endovascular aortic repair (FEVAR)	Yes, 33 mmHg (maximus), 41 (medius/minimus), 24 (tensor fascia lata)	Full power and sensation in limbs 1-month post-FEVAR, discharged to home on post operative day #6
Hayden	1	Non-iatrogenic: Trauma, cyclist hit by van in a MVA	No	Neuropathic pain is the S2/S3 region at 3 months post-operation
Heyn	1	Iatrogenic: OR-induced, intra-operative lithotomic positioning	Yes, 92 mmHg	Full recovery at one year with intensive physiotherapy
Horer	1	Iatrogenic: OR-induced, morphine injection into gluteus	Yes, 70 mmHg	Pain, neuropathy, and motor dysfunction at 3 months follow-up
Iizuka	1	Non-iatrogenic: Prolonged immobility, secondary to ethanol abuse, patient found down	Yes, 37 mmHg	Resolution of sciatic nerve palsy, ambulatory without crutches
Kao	1	Non-iatrogenic: Prolonged immobility, secondary to ethanol and drug abuse,	No	Right foot drop

		patient found down		
Keene	1	Iatrogenic: OR-induced, intra-operative lithotomic positioning	Yes, Left - 75 mmHg (tensor fascia lata), 60 mmHg (medius/minimus), 30 mm Hg (maximus), Right - 70 mm Hg (tensor fascia lata), 60 mm Hg (medius/minimus), 25 mm Hg (maximus)	No sequela, discharged home on post-operative day #6
Kong	1	Non-iatrogenic: Prolonged immobility, secondary to drug overdose in a suicide attempt	No	Recovery without loss of sensation and motor function
Kumar	4	Iatrogenic: Prolonged immobility folliowing joint arthroplasty	No	Recovered well
		Iatrogenic: Prolonged immobility folliowing joint arthroplasty	No	Recovered well
		Iatrogenic: Prolonged immobility folliowing joint arthroplasty	No	Recovered well
		Iatrogenic: Prolonged immobility folliowing joint arthroplasty	No	Trendelenburg gait due to loss of hip abductors
Lawrence	1	Non-iatrogenic: Prolonged immobility, secondary to ethanol abuse, patient found down	No	Trendelenburg gait due to loss of hip abductors
Lederman	1	Non-iatrogenic: Prolonged immobility, secondary to drug abuse	No	Right foot drop, pain
Liu HL	1	Non-iatrogenic: Prolonged immobility, secondary to drug abuse	Yes, 36 mmHg	Severe right sciatic nerve degeneration resulting in mobility impairment, patient wheelchair bound
Liu CY	1	Non-iatrogenic: Prolonged immobility, secondary to drug overdose from schizophrenia medication	No	Necrosis of bilateral gluteal muscles, Sciatic neuropathy, Foot drop at a 3 months follow-up

MacKay	1	Non-iatrogenic: Trauma, gunshot wound to thigh causing diffuse interstitial edema	Yes	No sequela
Mar	1	Iatrogenic: OR-induced, secondary to spinal epidural anesthesia	Yes	Recovery with minor morbidity
Matta	1	Iatrogenic: OR-induced, patient placed in the lateral decubitus position for >6 hours	Yes, 45 mmHg	No sequela, discharged home on post-operative day #8
McGoldrick	1	Iatrogenic: OR-induced, hemorrhage secondary to bone marow biopsy on patient previously anticoagulated	No	Right foot drop
Mitsiokapa	1	Non-iatrogenic: Prolonged immobility, secondary to drug abuse	No	Lumbosacral plexus injury in left lower extremity
Mustafa	1	Non-iatrogenic: Trauma, suspected fall secondary to severe sepsis	No	No sequela, discharged home on post-operative day #5
Narayan	1	Non-iatrogenic: Prolonged immobility, secondary to ethanol and cocaine abuse, patient found down	No	Left foot drop
Oates	1	Iatrogenic: OR-induced, obesity-related, masked by pre-existing back pain	No	Death
O'Leary	1	Iatrogenic: OR-induced, obesity-related, masked by epidural hematoma investigation	Yes, 54 mmHg	No sequela, discharged home on post-operative day #8
Osteen	1	Iatrogenic: OR-induced, statin-related	No	No sequela, discharged home on post-operative day #5
Panagiotopoulos	1	Non-iatrogenic: Prolonged immobility, secondary to nasal drug abuse	No	Sciatic nerve palsy, limited mobility & neuropathic pain
Pereira	1	Iatrogenic: OR-induced, obesity-related, intra-operative positioning (needed more padding)	Yes, 65 mmHg	No sequela, discharged home on post-operative day #35
Polacek	1	Iatrogenic: OR-Induced, obesity related, secondary to hypoperfusion	No	No sequela, discharged home on post-operative day #12

Rudolph	1	Iatrogenic: OR-Induced, obesity related, secondary to hypoperfusion	No	Slight renal impairment, gluteal pain & muscle insufficiency; D/C'd to rehab in wheelchair
Shaikh	1	Non-iatrogenic: Prolonged immobility, secondary to crush injury	No	Right foot drop, discharged home on post-operative day #40
Smith	1	Non-iatrogenic: Trauma, superior gluteal artery bleed due to fall (no fracture)	No	No sequela, discharged home
Songur	1	Non-iatrogenic: Trauma, Superior gluteal artery bleed, secondary to crush injury with pelvis ring fractures	No	No sequela, returned to work; reported at 6 month post-operative visit
Spratt	1	Non-iatrogenic: Trauma, inferior gluteal artery bleed due to MVA (no fracture)	No	No sequela, discharged home on post-operative day #7
Sullivan	1	Iatrogenic: OR-induced, hemorrhage secondary to bone marrow biopsy (aneursym of superior gluteal artery)	No	Walks with stick at 6 weeks, discharged home on post-operative day #1
Tasch	1	Non-iatrogenic: Prolonged immobility, secondary to drug abuse	Yes, 62 mmHg (measured 3 times)	Weakness in right quadriceps muscle and ankle, Hypersensitivity in right lower extremity
Taylor	1	Non-iatrogenic: Trauma, superior gluteal artery injury secondary to hip dislocation from MVA	No	Mild abductor weakness at 15 months post-operation,discharged home on post-operative day #2
Viviani	1	Iatrogenic: OR-induced, secondary to hypoperfusion from common iliac artery thrombus	Yes, Right - 111 mmHg, Left - 25 mmHg	Impaired mobility at 6 months post-operation, EMG showed post-ischemic primitive muscle injury
Woon	1	Non-iatrogenic: Overexertion, acute gluteal strain with hematoma and bacterial superinfection	Yes, Right - 58 mmHg, Left - 4 mmHg	No sequela, discharged home on post-operative day #6
Young Cho	1	Non-iatrogenic: Prolonged immobility, secondary to ethanol, patient found down	No	Bilateral permanent foot drop

Discussion

With only 49 reported cases in the last 10 years, GCS is a rare clinical entity. Due to its rarity, a high index of suspicion is imperative for clinicians, especially when the mechanism of injury places the patient at high risk for the disorder. In our study, iatrogenic injury was the most common cause. Therefore, surgeons should be mindful of patient positioning in the operating room and consider periodic rotation of the patient when the surgical procedures are lengthy. Specifically, positioning in lithotomy, where a patient's lower extremities are above or at the same level as the hips, can predispose a patient to developing GCS. For patients who are found down secondary to drug abuse, the gluteal compartments should always be examined and monitored. Lastly, traumatic injuries to the pelvis should be followed closely, especially in high-energy mechanisms.

The diagnosis of GCS was made with clinical examination in the majority of cases. The clinical exam findings were varied amongst patients, ranging from firmness and swelling of the buttock and/or thigh to decreased motor strength and decreased or absent lower extremity deep tendon reflexes. Compartment pressure measurement was used to confirm diagnosis once GCS was suspected. Several modalities were used to measure compartment pressures including wick catheter, 20-gauge needle attached to a central venous pressure monitor, 18-gauge needle connected to a transducer, and a compartmental measuring tool using Whitesides technique. As such, we recommend that once GCS is suspected, an intracompartmental pressure measurement should be performed. However, if there is any difficulty with obtaining a pressure or there is a delay in obtaining equipment and clinical suspicion is high, fasciotomy should not be delayed. Current recommendations suggest that compartmental pressures >30 mmHg should be treated with emergent fasciotomy [12].

Our analysis also showed that the mechanism of injury was correlated to the final clinical outcome. Patients who developed GCS due to prolonged immobilization were found to have the highest incidence of permanent sequalae. We postulate that this likely related to increased time from injury to treatment and further supports that prompt attention and appropriately aggressive treatment is key to achieving better clinical outcomes. Iatrogenic mechanisms tend to be identified at relatively earlier point in time following injury, which accounts for their high rate of recovery and low rate of permanent sequelae.

Furthermore, clinical management was also correlated with outcome. Cases that were managed non-operatively had higher percentages of permanent sequelae. Of the 6 cases, one patient had brachial plexus injury that complicated the clinical picture leading to a missed diagnosis of GCS. Two other cases did not report their reasoning behind their choice to manage non-operatively. In another case, the gluteus was not tense on physical exam leading to the decision to not perform a fasciotomy. In two cases, GCS was already present for an extended period of time; one reported 48 hours and another >8 hours. The clinicians managing these patients did not feel they would benefit from surgical intervention since the muscles and nerves in the gluteal compartments were likely no longer viable. None of the cases discussed any contraindications to surgery. However, it is important to note that 4 of 6 cases that were managed non-operatively were patients who had prolonged immobilization due to substance abuse, and this was the mechanism with the highest incidence of permanent sequelae. It is difficult to state the appropriate timeline for surgical intervention in GCS due to lack of clarity of the reported timelines within the case reports.

The complications from GCS can be life threatening, as shown by the case of the patient who died due to multisystem organ failure. Patients who had surgical intervention had a higher percentage of full recovery than those who were managed non-operatively.

Additionally, our literature review revealed a low risk of infection in surgically managed GCS patients. There exists evidence in the literature that delayed fasciotomy in the extremities has higher rates of amputation and mortality. One study found that patients who underwent delayed fasciotomies had twice the rate of major amputation and a threefold higher mortality [37]. Another study on delayed fasciotomy in extremities concluded that if recognition of an established compartment syndrome is delayed for more than 8 to 10 hours, fasciotomy should be reconsidered [6]. Consequently, it can be argued that GCS should be managed operatively regardless of timing. This argument was also made in several of the papers within the literature search.

Beyond this, 4 cases within our search utilized angioembolization in combination with fasciotomy. It is important to note that embolization before fasciotomy can reduce the risk of massive blood loss since uncontrolled bleeding may be hard to localize and ligate during the procedure due to poor visualization.

In comparison to the first systematic review of the literature by Henson et. al, our review had a higher number of cases (49 versus 28) [12]. This leads us to believe that this disorder is being recognized and treated more frequently. Henson et. al reported that prolonged immobilization was the most common cause while we found that iatrogenic GCS was the most common cause. Similarly, Henson et. al concluded that intracompartmental pressures are helpful, but diagnosis is mostly clinical. The majority of the patients included in both reviews were treated surgically.

Ultimately, more investigation is needed to better understand and outline the mechanisms, treatments, and outcomes of gluteal compartment syndrome. Specifically, there is limited data regarding surgical technique/approach, timing to diagnosis, wound closure methods, and post-operative care. Additionally, an area for preventive measures, such as routine repositioning during prolonged procedures in the operating room is also of interest.

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Conflicts of Interest

The authors state that there is no conflict of interest.

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