

Well Leg Compartment Syndrome After Abdominal Surgery

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Abstract

Background Well leg compartment syndrome (WLCS) is a complication to abdominal surgery. We aimed to identify risk factors for and outcome of WLCS in Denmark and literature.

Methods Prospectively collected claims to the Danish Patient Compensation Association (DPCA) concerning WLCS after abdominal operations 1996–2013 and cases in literature 1970–2013 were evaluated. Cases of fasciotomy within 2 weeks after abdominal surgery 1999–2008 were extracted from the Danish National Patient Register (DNPR).

Results There were 40 cases in DPCA and 124 in literature. In 68 % legs were supported under the knees during surgery. Symptoms of WLCS presented within 2 h after surgery in 56 % and in only 3 cases after 24 h. Obesity was not confirmed as risk factor for WLCS. The mean diagnostic delay was 10 h. One-third of fasciotomies were insufficient. The diagnostic delay increased with duration of the abdominal surgery ($p = 0.04$). Duration of the abdominal surgery was 4 times as important as the diagnostic delay for severity of the final outcome. DNPR recorded 4 new cases/year, and half were reported to DPCA.

Conclusion The first 24 h following abdominal surgery of >4 h' duration with elevated legs observation for WLCS should be standard. Pain in the calf is indicative of WLCS, and elevated serum CK can support the diagnosis. Mannitol infusion and acute four-compartment fasciotomy of the lower leg is the treatment. The risk of severe outcome of WLCS increases with duration of the primary operation. A broad support and change of legs' position during surgery are suggested preventative initiatives.

Introduction

Well leg compartment syndrome (WLCS) is an infrequent complication to abdominal surgery. In a retrospective 40-year review from the Mayo clinic, the occurrence was estimated to 1:3.500 of patients at risk (=0.03 %) [1], but there are probably many mild, subclinical or unrecognized forms of the syndrome. In 3110 cases of robot-assisted radical prostatectomy, nine WLCS cases were reported (=0.29 %) [2]. Compartment syndrome was first reported in association with surgical positioning in 1872 [1] and

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with prolonged lithotomy position in 1979 [3]. Onset of symptoms is usually within 12 h postoperatively, but may be after 24 h or more. Suggested risk factors for WLCS are obesity, peripheral vascular disease, long operation time and time in lithotomy position [1, 3].

Destruction of muscle in WLCS results in release of myoglobin, and this large molecule can lead to kidney failure with increasing serum creatinine and serum potassium. Nerve injury and distal ischemia can occur. Treatment is acute fasciotomy [4, 5].

Almost all publications on WLCS are case reports and might be unrepresentative for the condition and risk factors. Therefore, we found it of interest to describe the occurrence of WLCS after abdominal surgery in a whole country (Denmark). We aimed to identify potential risk factors for this complication and its final outcome in our cases and cases reported in literature.

Materials and methods

In Denmark, patients can free of charge claim financial compensation from the Danish Patient Compensation Association (DPCA) for a complication to treatment or examination in the Danish health care system. If health care persons suspect that a complication might have occurred, they have an obligation to recommend the patient to submit a claim to DPCA. If a claim is accepted, compensation is granted by the public or private health organization connected to the complication, or by an insurance company. Details about all claims are prospectively registered and coded in a database in DPCA, including the diagnostic code of the complication and the ICRS code of the procedure leading to the complication.

From this database, we identified patients with a compartment syndrome of the calf as complication to abdominal surgery. There were 40 cases 1996–2013, and we extracted the following information from the medical files: weight, height, duration of operation, method to suspend the legs during operation, time of debut symptoms of WLCS after the primary operation, time when treatment was initiated, treatment of WLCS and in case of fasciotomy whether an additional fasciotomy had been performed later (in which case the first fasciotomy was evaluated as insufficient), the final outcome of WLCS, and the compensation to the patient. “Doctor’s delay” was defined as the time from when the diagnosis could have been established (judged from clinical information) to the time, when treatment was actually performed.

Literature searches in PubMed on acute compartment syndrome as complication to abdominal surgery were performed for 1970–2013. There were no randomized studies. Based on the abstracts, 54 relevant papers with 78

cases were identified. From the references in these, we identified additional 15 papers, increasing the literature series to 125 cases ([2, 3, 6–11], a full list of papers available from the authors). We extracted the same information as above (except the compensation) from the cases in literature. Two case reports originated from Danish hospitals, and one had been reported to DPCA. Therefore, the total number of cases was 164.

To evaluate the completeness of the claims to DPCA, we obtained information about the number of patients who had a fasciotomy of the lower leg performed within 2 weeks after a gastrointestinal, urologic, gynecologic or plastic surgery procedure 1999–2008 from the National Registry of Patients, to which all operations in Denmark are reported.

Statistical methods

Data are presented as median and range

The associations between diagnostic delay, primary operation time (of the abdominal surgery) and the severity of the final outcome were examined by pairwise correlations, and the strength of the associations was found by uni- and multivariable regression. The literature cases and the DPCA cases were analyzed separately and combined. All cases with missing variables were excluded from the analyses, and one case was excluded from the parametrical analyses as an outlier, because of an extreme high value for the diagnostic delay (216 h = >16 standard deviations). Severity of the final outcome was categorized as good, acceptable, poor, and bad, and scored as 0, 1, 2, and 3, respectively. Stata 14.1 was used for all analyses (StataCorp, College Station, TX 77845).

Results

Most cases of WLCS were reported 1991–2007 (71 patients of 125).

The clinical data of the patients are given in Table 1. The median surgery time for gastrointestinal and urological

Table 1 Clinical details of the 164 patients with WLCS

	Literature	DPCA
Number	124	40
Male/female	69/46 (9 unknown)	27/13
Age (mean and range)	43 (7–80) (9 unknown)	50,3 (16–81)
BMI		
Normal (BMI < 25)	59	22
Overweight (BMI 25–29)	21 (16.9 %)	11 (27.5 %)
Obesity (BMI ≥ 30)	8 (6.5 %)	6 (15 %)
Unknown	35	1

Table 2 Methods to suspend the legs during operation in 164 patients

	Literature	DPCA
Support under the knees	66	40
Support under the knees and the feet in stirrups	18	0
Lloyd-Davies position [12]	24	0
Lloyd-Davies position and feet in Allen stirrups	4	0
Prone with stretched legs	2	0
Legs suspended in special bags from thighs to feet	1	0
Unknown	9	0

operations was 7.0 and 8.1 h, respectively, in literature and 5.9 and 5.0 h in the Danish patients.

The methods used to suspend the legs during operation are listed in Table 2, and the details of the complicating WLCS in Table 3. In 56 % the initial symptoms of WLCS appeared with 2 h after the primary operation, and 50 % had symptoms immediately after the operation. The median doctor's delay was 10 h. There was no doctor's delay in 27 cases. For 90 of the cases in literature there was information, which made it possible to test for correlations between operation time/doctor's delay and the severity of

the final outcome of WLCS. In literature, the severity of the final outcome increased with the duration of doctor's delay as well as with the duration of the operation, but only significantly for the operation time ($p = 0.03$). The same was found in the data from DPCA. The diagnostic delay increased 5 h per hour operation time of the primary surgery ($p = 0.04$; 95 % CI 0.3–9.5 h). Controlling for the diagnostic delay weakened the strength of association between duration of primary operation and severity ($p = 0.4$ and $p = 0.1$ for multi- and univariable regression, respectively), whereas diagnostic delay was an independent significant predictor of the severity of the final outcome ($p = 0.02$ and 0.01 for multi- and univariable regression, respectively). Hour for hour the duration of the primary operation was approximately 4 times as important for severity of the final outcome as diagnostic delay.

Fasciotomy had to be repeated in one-third of the cases in both groups. Sixteen cases were handled without fasciotomy, and in these the clinical results were bad in 4, poor in 2, acceptable in 5 and good in 5.

Of the 40 patients who had a claim with DCPA, 24 (60 %) received compensation, totaling 1.236.500 USD.

The Danish National Registry of Patients had 38 patients registered with a fasciotomy of the lower leg performed

Table 3 Details about the primary operation, WLCS and final outcome in 164 patients

	Literature	DPCA
Number of cases	124	40
Type of surgery		
Colorectal	50	32
Gynecologic	21	5
Obstetric	1	
Plastic	2	1
Urologic	50	2
Duration of surgery (hours, median and range)	7,5 (2–12)	6 (3,5–9)
Debut of symptoms after surgery (hours, median and range)	2 (0–96)	0 (0–40)
Debut of symptoms >24 h after surgery (number of patients)	2	1
Doctor's delay (hours, median and range)	10 (0–80)	10 (0–216)
Fasciotomy		
Sufficient 4 compartment	45	25
Insufficient 1–3 compartment	25	9
Unknown/not described	42	0
Fasciotomy not performed	12	6
Final outcome		
Full recovery	31	1
Only sensory deficit in lower limb	24	13
Pain and sensory deficit in lower limb	22	14
Paresis, pain and sensory deficit in lower limb	34	12
Major bilateral amputation	1	0
Unknown	11	0
Death from pulmonary embolism at 3 weeks	1	0

within 2 weeks after a gastrointestinal, urologic, gynecologic or plastic surgical procedure 1999–2008. As 15 % of patients with WLCS are not treated with fasciotomy, the number of patients with WLCS may be underestimated. On the other hand, fasciotomy may have been performed for other reasons than WLCS. During the same 10-year period, DPCA registered 19 claims of WLCS, indicating that about half of the cases in Denmark were reported to the DPCA. The incidence of WLCS on this basis is about 1 case/year/million inhabitants.

Discussion

Our report is the largest series of WLCS following operations in which the lithotomy positioning of the legs was used. The clinical data of our patients were slightly different from literature, as they were older, with a higher proportion of males and a higher proportion of overweight and obese patients. The majority of the operations were colorectal, but there was a much higher proportion of urological operations reported in literature. Danish urologists generally use the lithotomy position for radical prostatectomy and cystectomy, as in the cases from literature. However, the median operation time for urological operations reported in literature was 3 h longer than in the 2 Danish cases, and during the time period investigated operations of long duration were probably much more common internationally than in Denmark. Also, many of the earliest case reports regarding WLCS related to urological operations, and internationally urologists might therefore have paid special attention to this complication and reported it more often.

Obesity has been hypothesized as predisposing to WLCS because of the larger weight of the leg, and in a report of 9 cases after urological operations 5 were obese [2]. However, the increased thickness of subcutaneous fat in obese persons might provide force distribution and reduce the direct pressure on muscles. The frequency of overweight/obesity was 16.9/6.5 % in the world literature but higher (27.5/15.0 %) in the Danish patients. This is surprising, as obesity is less common in Denmark with a prevalence of about 12 % [13] compared to 35 % in the USA and other Western countries [14]. BMI was not reported for 30 % of the patients in literature, though. Even though the number of cases in our series is small, the proportion of obese patients was not higher than in the Danish population, and most patients with WLCS were not obese, indicating that obesity is not a general risk factor.

The common denominator for development of WLCS is a long operating time, and operating time was about 4 times as important for the severity of the final outcome of WLCS as the delay of the diagnosis. However, long

operation time was also associated with longer diagnostic delay. The reason for this might be that longer operation times are more likely to be associated with complicated postoperative conditions calling for specific observation. These patients are also likely to have been more heavily sedated, masking pain, thereby reducing the possibilities of early diagnosis of WLCS. WLCS is very rarely reported to develop in operations that last less than 4 h, which is also the case in our series. No general safe time limit can, however, be identified [10, 15]. We suggest that regular physical examination of the leg, e.g., once every hour, during the first 24 h is included in the observational protocol after abdominal operations with the legs in lithotomy position, in order to reduce the diagnostic delay of compartment syndrome.

The lithotomy position reduces the blood pressure in the leg in healthy persons [15]. If the lithotomy position is used only during the part of the operation when it is necessary for technical reasons, or if elevation is discontinued regularly during surgery by lowering it might reduce the risk for WLCS [15]. This may be inconvenient during the surgical procedure, but leg holders that permit automatic lowering could be a realistic option [16, 17].

The pathophysiological mechanism for WLCS is probably related to reperfusion. When the elevated leg is supported under the knee or calf, pressure is applied to the leg muscles and the popliteal vessels and nerves. Simultaneously the arterial blood pressure in the leg is reduced due to elevation and flexion of hip and knee [15] and the systemic reduction of blood pressure caused by anesthesia. These factors result in microvascular damage and ischemic injury to the muscle tissue. When the leg is lowered, reperfusion causes inflow of fluid to the damaged musculature, and this increases the compartmental pressure, leading to impaired blood flow and reduced oxygenation [1].

The way legs are secured in the lithotomy position is theoretically important in prevention of WLCS. Pressure on the popliteal vessels can be avoided by use of foot stirrups or boots [9, 17]. One Danish hospital reported 7 cases of WLCS to DPCA 1996–2000. Subsequently they positioned their patients with special boots avoiding direct pressure on the lower leg, and the number of patients with WLCS decreased [9]. However, in literature WLCS is reported following any position of the legs.

The frequency of WLCS in abdominal operations using the lithotomy position was calculated to be 0.03 % in one classic study [1]. But as we have been able to collect 24 % of the total number of cases of WLCS in the literature from a country with 5.7 million inhabitants, there is probably a large underreporting of this complication. The risk of WLCS in urology was investigated in 2005 by questioning 291 British consultants [18] and was estimated to be 0.2 % among patients at risk. Almost the same risk was reported

in a multicenter study regarding prostatectomy [2]. It has not been possible to obtain information about the number of patients at risk in Denmark during the study period, so we cannot calculate the risk for WLCS after operations in the lithotomy position, but we can estimate the incidence to slightly less than 1/year/million inhabitants.

This complication is so rare that many surgeons will never see it, and this may explain a significant “doctor’s delay.” The syndrome is often confused with deep venous thrombosis, leading to time-consuming diagnostic investigations. We found that in more than half of the cases the first symptom of WLCS occurred within 2 h after surgery. Even though during the first hours after major surgery there is primary focus on vital aspects of the patient’s condition, observation of the legs should be part of standard procedures. Clinically it shows as pain in the lower leg after the lithotomy position, and it can be diagnosed through manual evaluation of compartment pressure or manometry. An elevated serum concentration of creatine kinase (CK) of more than 2000 U/l is very unusual after surgery [8] and is a confirmation of WLCS, when symptoms are present. In our series, one patient had a serum CK of 40,000 U/l. After lower leg fracture, a serum CK of more than 4000 U/l is regarded as a cut point in diagnosis of compartment syndrome [19], and a rapid increase in serum CK is described at 2 h after injury [20]. So, in addition to regular clinical examination of the legs, measurement of serum CK 2 h postoperatively in patients at high risk for WLCS as part of the postoperative protocol could be effective to reduce the diagnostic delay of WLCS, in particular in sedated patients.

Logistics with involvement of surgeons, anesthetists and orthopedic surgeons, when WLCS is suspected calls for a close teamwork, which is not always available. It is simpler when a compartment syndrome occurs in an orthopedic patient and the treatment rests within the same speciality [21]. If WLCS is suspected, immediate mannitol infusion should be given to increase the osmotic capacity of serum and possibly reduce the edema in the muscles in the waiting time for acute fasciotomy [6, 8, 22].

The use of anti-thrombosis compression stockings may decrease blood flow in the legs and therefore contribute to development of WLCS [1]. In a series of 9 patients with WLCS after radical prostatectomy, pneumatic compressive stocking had been used in all cases [2]. When WLCS is suspected, stockings should probably be removed, and prophylaxis against venous thrombosis should be medical.

Based on an orthopedic case in which the diagnosis of WLCS was delayed to the eighth postoperative day, it has been suggested that postoperative epidural analgesia may obscure symptoms of WLCS and delay diagnosis [23]. We found no examples where this had caused a delay in diagnosis. An epidural analgesia is typically placed at the thoracic level in gastrointestinal and urologic procedures.

The analgesic effect of this to the lower lumbar regions supplying the calf is often minimal, and pain sensation in the lower leg is largely undisturbed [7].

The fasciotomy was found to be technically insufficient in 34 of 104 surgeries (33 %). This is probably caused by misjudgement regarding the extent of the tissue damage. As WLCS is caused by mechanisms that affect the whole calf, a full four-compartment fasciotomy should be standard in these cases.

Compliance with ethical standards

Conflicts of interest The authors declare no conflicts of interest.

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