URINARY TRACT LESIONS IN CESAREAN SECTIONS
INCIDENCE AND MODALITY OF DIAGNOSIS

- A systematic literature search

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1. ABSTRACT

Objective: To perform a systematic literature search on the frequency of urinary tract lesions in cesarean sections, and to identify recommendations on diagnostic modalities.

Method: A systematic computerized literature search in PubMed and Embase databases was last conducted on December 2nd, 2021. After the removal of duplicates, the search resulted in 665 hits. The articles were screened by one medical student for relevance by title and abstract. 43 articles were included and read in full text.

Results: Injuries to the bladder and the ureters during cesarean sections occur infrequently. The incidence of injuries to the urinary tract varies between 0.05% and 0.47% for bladder injuries. While the incidence for ureter injuries varies between 0 and 0.11%. Even though these incidents happen infrequently, obstetricians need to obtain proper knowledge about prevention, diagnosis and management when they occur. Bladder injuries can be detected intraoperatively through direct observation and be confirmed by the instillation of methylene blue or indigo carmine through a urinary catheter. Ureter injuries can be investigated through cystoscopy with intravenous injection of indigo carmine to observe the discharge from the orifices of the ureters or to execute a bilateral catheterization. If these methods do not provide sufficient information, it is advised to perform a retrograde intravenous pyelogram to confirm the intactness of the ureters. If symptoms arise postoperatively, confirmation of diagnosis can be done by ultrasound, intravenous pyelogram and abdominal computer tomography (CT).

Conclusion: Bladder and ureter injuries happen infrequently. In order to avoid short- and long-term complications, obstetricians need to be aware of risk factors, symptoms and diagnostic modalities whenever suspicion for injuries to the urinary tract is raised.
2. ACKNOWLEDGEMENTS

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3. INTRODUCTION

WHO states that the global rate of cesarean section (CS) continues to rise, but without significant benefit to maternal or perinatal health. (1, 2) When CS is medically indicated, the potential of saving lives weighs out the risk of possible iatrogenic short- and long-term complications. Whenever CS is contemplated based on reasons that are not medically justifiable, it is crucial to provide the mother with sufficient information about potential complications and consequences concerning the different courses of action. If CS is still requested, the value of empowerment in decision-making and every woman’s unique needs and requests should be taken into account. At the same time, it is important to secure that both women and their fetuses are not exposed to unnecessary short- and long-term complications.

As the rate of CS increases, it is reasonable to speculate whether the rate of complications will rise accordingly. Iatrogenic injuries to the urinary tract during CS happen relatively rare. (3, 4) These injuries can cause potentially serious complications. Consequently, it is very important to establish good practice for the assessment and management of these injuries. Obstetricians need to be cognizant of risk factors, intraoperative and postoperative diagnosis, and how to manage these injuries. A high index of suspicion increases the likelihood of a perioperative diagnosis. An immediate repair is associated with a better prognosis and reduces morbidity, expenses and the potential need of a second operative intervention. (5, 6) The goal is to secure the most favorable outcome for every mother and to prevent complications.

The aim of this study is to perform a systematic search for literature of the frequency of urinary tract lesions in CS and to identify recommendations on diagnostic modalities.
4. METHOD

A systematic computerized literature search in PubMed and Embase databases was last conducted on December 2nd, 2021 by one medical student (NL). The main focus of the search was to find articles concerning women undergoing CS with injuries to the urinary tract as a complication. Articles published between 1995-2021 were included. Languages were restricted to English and Scandinavian. No further exclusion criteria were applied as long as the abstract was suitable for the subject of interest.

The following advanced search was conducted in PubMed:

* Cesarean Section AND Urinary tract AND (injury OR injuries OR damage OR damages OR lesion OR lesions) AND (English[lang] OR Norwegian[lang] OR Swedish[lang] OR Danish[lang]) AND "last 26 years"[PDat]

This search covered title, abstract and end words, and resulted in 241 hits. 27 of these were included according to relevancy to the subject of interest.

The following search and limitations were conducted in Embase, using a combination of title words and subject headings from the controlled vocabulary EMTREE;

1.  Cesarean section/
2.  Exp Urinary tract/
3.  (injury or injuries or damage or damages or lesion or lesions).ti.
4.  Exp urinary tract injury/
5.  (2 and 3) or 4
6.  1 and 5
7.  Limit 6 to English language
8.  Limit 7 to yr="1995-current"
9.  Limit 8 to article

The search resulted in 497 hits. After the removal of duplicates related to the search done in PubMed, we were left with 424 hits. 16 of these were included.
A total of $241 + 424 = 665$ articles were screened by title and abstract by the same 4\textsuperscript{th}-year medical student (NL). 43 articles were further thoroughly reviewed. Throughout the reading, information were reported in a literature matrix and further distributed in groups according to thematic to facilitate comparison of the different views.

**Figure 1: Study Inclusion Flow Chart.**
5. BLADDER INJURIES

Figure 2: Illustration of the bladder and ureters. Available from https://smart.servier.com/smart_image/bladder/ (Obtained with permission: 21.12.21).

5.1 INCIDENCE

Throughout reviewed literature, the incidence of injuries to the bladder remains low. Salman et al report 81 accidental cystotomies in a retrospective series of 17,326 CS from 2007-2016. (3) This represents an incidence of 0.47%, which is the highest found in the reviewed literature. The lowest incidence is reported by Naicker et al to be 0.05%, and it is from a recent 5-year retrospective case study conducted in South Africa. (4) Safrai et al present a single-center retrospective cohort study from 2004-2018 where the incidence of injuries to the bladder is 0.08%. (7) Rahman et al report an incidence of 0.44%. (8) In a 5-year retrospective study by Eisenkop et al, the incidence of bladder injuries is 0.31%. (9) Hence, the incidence of accidental cystotomies varies between 0.05% and 0.47% in reviewed studies. All incidents found in reviewed literature are listed in figure 9.
5.2 RISK FACTORS

Figure 3: Overview of potential risk factors associated with bladder injuries.

5.2.1 ADHESIONS AND REPEAT CESAREAN SECTION

Throughout reviewed literature, the formation of adhesions from prior CS or other pelvic surgery appears to be a significant risk factor. (3-5, 8-14) Adhesions between the bladder and lower uterine segment tend to complicate both the opening of the peritoneal cavity and the retraction of the bladder flap. (8, 9) If adhesions are present, careful sharp dissection is the recommended approach in the separation of the bladder from the uterus. (4, 8, 9) In many studies, the incidence of bladder injury is consequently higher during repeat CS. (9, 11)

Gungorduk et al report that previous CS and adhesions are associated with a 5-10 fold increased risk for accidental cystotomy. (5) As a consequence of an earlier CS, the bladder can be placed in a higher position in the abdomen. (6) Phipps et al present that there is a 4-fold increased risk for bladder injury among women with prior CS. (10) Salman et al state that 90.1% of the women diagnosed with bladder injury had one or more previous CS.(3) Rahman et al report that 58.8% of the women with bladder injury had repeat CS, and that prior CS increases the risk 4-fold.
compared to primary CS. (8) Gungorduk et al present that 72.4% of the women in their case group with bladder injury had a prior CS, while the incidence is 34.2% in the control group. (5) Phipps et al and Chill et al also report that the incidence is higher in the “repeat CS-group” and among the patients with adhesions during the procedure. (10, 15) In the study by Al-Shahrani et al, the findings of adhesions are consistent with others. They also conclude that women with three or more CS are more prone to bladder injury. (11) Abdelazim et al present that the risk for dense omental adhesions is higher and that bladder injuries are 5-times more likely to occur in women with three or more CS, compared to women with only one previous CS. (16) On the other hand; Rajasekar et al suggest that prior CS or abdominal surgery does not increase the risk for urinary tract injuries. (17) However, they propose that their inconsistent findings in comparison to the other studies can be explained by their practice of prioritizing experienced senior obstetricians and more supervision for women with remarkable risk factors. (17) The experience of the obstetrician will be further reviewed in 5.2.9.

5.2.2 Elective cesarean section
A recurrent topic in the reviewed literature is whether injuries occur more frequently during elective or emergency CS. Indications for elective CS include; Previous CS, breech position of the fetus, placenta previa and twin deliveries. (3) Those who report a higher rate of complications to the urinary tract in the elective group, usually refer to that the fact that elective CS usually are executed in older and multiparous women, who are more prone to have adhesions from previous CS. (5, 8, 10, 13, 15) Rahman et al present an incidence of 61.8% in the elective group versus 38.2% in the emergency group. (8) In a study by Naicker et al, 84.3% of women with lower urinary tract injuries during obstetric interventions are multiparous. (4) On the other hand; in a study by Rajasekar et al, none of the women with accidental cystotomy had a previous CS, and 14 of 16 women were primigravida. (17) In both studies, most women with injuries to the urinary tract did have an emergency CS.

5.2.3 Emergency cesarean section
Indications for emergency CS include a pathological fetal heart rate, protracted descent, abnormal cervical dilatation, unsuccessful induction, chorioamnionitis, breech position of the fetus, placental abruption or twin delivery. (3) Yossepowich et al and Phipps et al conclude that emergency CS have a higher risk of injuring the urinary tract, because of stressful circumstances
for the operator and the possibility of not being able to sufficiently prepare the patients for the intervention. (10, 18) For instance, there might not be time to empty the bladder before surgery. When the priority is to rapidly deliver a hypoxic fetus, the dissection might not be as careful as it should be. (19) Phipps et al present that in the group of women with bladder injuries, 62% had a prior CS and potentially adhesive formations. (10) The incidence of damage to the urinary tract is also higher in emergency CS in studies by Rajasekar et al, Al-Sharani et al and Lo et al. (11, 17, 20) Hammad et al, on the other hand, report that there is no difference in the incidence of injuries between elective and emergency procedures. (21)

### 5.2.4 UTERINE INCISION EXTENSION

Unintended and uncontrolled hysterotomy tears both downwards or laterally can cause injuries to both the bladder and ureters. (15) Chill et al present that the size of a hysterotomy tear has an odds ratio (OR) of 1.42 (95% confidence interval (CI) 1.05-1.93) in relation to bladder injuries.(15) The extension can give rise to uncontrolled hemorrhage, which also increases the risk for ureter injury during the application of hemostasis through the placement of blind sutures. (9, 17, 18, 20, 22) This event will be addressed under ureter injuries.

### 5.2.5 UNSUCCESSFUL VACUUM-ASSISTED DELIVERY BEFORE CS

Chill et al also report an OR of 4.37 (95% CI 1.11-17.2) for bladder injuries, whenever vacuum-delivery is attempted before CS. (15) When the fetal head is at a low station in the pelvis, it might cause a substantial distension of the lower uterine segment, which increases the risk of hysterotomy extension and further injuries. (15)

### 5.2.6 CS IN THE SECOND STAGE OF LABOR

Chill et al also investigate the relation between CS in the second stage of labor and bladder injuries. (15) Injuries are believed to happen more frequently during the second stage of labor because of the larger dilatation of the cervix and the low station of the fetal head. Tarney et al report that an arrest of the deep stationed fetal head can cause trauma in the area around the bladder and make it difficult to identify the anatomy. (19) In a univariate analysis by Chill et al, a protracted second stage appears to be a significant risk factor for bladder injury. (15) However, these factors lost significance in their multivariate analysis. In a literature review by Tarney et al, the risk of accidental cystotomy is slightly increased during the second stage of labor. (19)
5.2.7 Placenta Previa and/or Accreta
Al-Shahrami et al report from their retrospective case-control study that women with placenta previa and/or accreta have a higher risk for bladder injury. It is possible that the placenta directly infiltrates the bladder, which makes a cystotomy necessary during surgery. (11)

5.2.8 Vaginal Birth After CS
Phipps et al also present that women who try vaginal birth after CS are more prone to bladder injuries. (10) There is a possibility for rupture or dehiscence of previous hysterotomies, which can potentially cause serious complications.

5.2.9 The Surgical Experience of the Obstetrician
Rajasekar et al note that most injuries happen when CS is performed by junior obstetricians, especially when they are without direct supervision from a senior obstetrician. (17) When remarkable risk factors for injuries to the urinary tract are identified, a senior obstetrician should be available at all times. Rajasekar et al and Naicker et al emphasize the importance of sufficient training of junior staff. (4, 17) Rahman et al also address that operator experience could be a risk factor. (8) According to Salman et al, a senior obstetrician is always present during CS in their study. (3)

5.2.10 Independent Risk Factors
Some studies report that there is no difference in the execution of Pfannenstiel incision versus the sub-umbilical midline incision. (5, 10) Gungorduk et al also present that the BMI were similar in both the case and control-group. (5) Phipps et al also state that the infant’s characteristics like birth weight, APGAR score, and blood-gas-results are similar in both case and control groups. (10) Al-Shahrani et al report no statistically significant difference in age of the women, their parity, gestational age, stage of the labor, multiple or single pregnancy, the position of the fetus at delivery and uterine scar rupture in their case and control group. (11)
5.3 TIME AND LOCALIZATION OF DAMAGE

According to reviewed literature, injuries to the urinary bladder usually occur during the entry to the peritoneal cavity, during the separation of the bladder flap or during the hysterotomy. (5, 8, 11) Gungorduk et al present that women with primary CS have a higher risk of bladder-lacerations during entry to the peritoneal cavity, while women with previous CS more frequently get bladder injuries during the separation of the bladder flap because of adhesions. (5) Rahman et al confirm that injuries in women with repeat CS happen more frequently during the separation of the bladder flap. (8) This was also the case in primary CS. Al-Shahrani et al state that most injuries happen during the peritoneal entry. (11, 13) On the other hand, Phipps et al report that 43% of the injuries occurred during the creation of the bladder flap, 33% during peritoneal entry, and 24% during the uterine incision or delivery. (10) Chill et al present most injuries during the uterine incision. (15) Salman et al report most injuries during the peritoneal entry (67.9%) and that the damage most often involved the bladder dome. (3) Most studies address the bladder dome as the dominant sight of injury. (10, 11, 15) Chill et al report that approximately 1/3 of the injuries take place at the posterior bladder wall. (15) The injuries at the posterior bladder wall are more likely to involve the ureters.
The timing of bladder injuries when the parity is unknown

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<tbody>
<tr>
<td>Peritoneal entry</td>
<td>33%</td>
<td>45.8%</td>
<td>22%</td>
</tr>
<tr>
<td>Bladder flap</td>
<td>43%</td>
<td>8.3%</td>
<td>18%</td>
</tr>
<tr>
<td>Uterine incision</td>
<td>24%</td>
<td>37.5%</td>
<td>60%</td>
</tr>
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</table>

Figure 5: Table showing the timing of bladder injury when parity is unknown.

The timing of bladder injuries during primary and repeat CS

<table>
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<tbody>
<tr>
<td>Peritoneal entry</td>
<td>35.7%</td>
<td>30%</td>
<td>46.6%</td>
<td>30%</td>
</tr>
<tr>
<td>Bladder flap</td>
<td>50%</td>
<td>60%</td>
<td>23.8%</td>
<td>43.3%</td>
</tr>
<tr>
<td>Uterine incision</td>
<td>14.3%</td>
<td>10%</td>
<td>28.6%</td>
<td>26.7%</td>
</tr>
</tbody>
</table>

Figure 6: Table showing the timing of bladder injury when parity is known.

5.4 INTRAOPERATIVE SIGNS, DIAGNOSIS AND MANAGEMENT

Early identification and repair of damage are important prognostic factors. (4, 5, 8, 9, 17, 18, 20) Bladder injuries are usually recognized intraoperatively. (5, 7, 8, 10, 11) During surgery, direct inspection is considered the most important method of recognizing injuries to the urinary tract. (5, 8, 11, 15) Other findings during the operation that should raise suspicion of injuries to the bladder are leakage of urine, visible damages to the detrusor muscle, appearance of foley bulb during the operation and severe hematuria in the catheter bag. (5, 8, 11) If there is any doubt about the intactness of the bladder, many authors suggest instilling methylene blue or indigo carmine in the Foley catheter. (5, 7, 8, 11) In cases of ambiguity or if a complicated injury is present, it is advisable to involve a urologist. (11) Safrai et al suggest to always involve a urologist whenever bladder injury is discovered, and to always check if the tear involves the posterior wall or trigone. (7) If this is the case, further examination of the intactness of the ureters should be done. The modality of choice regarding ureter injuries will be assessed later in this literature review. The involvement of a urologist can be beneficial in the planning process of CS.
in patients with many risk factors, for perioperative advisement and assistance, and if injuries are diagnosed postoperatively. (21)

To ensure bladder integrity after repair of both accidental and diagnostic cystotomy, some surgeons use a retrograde filling of the bladder with methylene blue. (5, 9) Chill et al report that leakage was present in 15.4% after repair. (15) Therefore, they suggest retrograde bladder filling as a part of the routine to confirm bladder integrity after repair, but they emphasize the need for further studies.

Saaqib et al present a randomized control trial from Pakistan 2017 to 2019. (23) They report that filling the bladder with saline can be a useful measure to help delineate the bladder and to execute further adhesiolysis in women with confirmed bladder adhesions from previous CS. (23) According to their trial, cystoinflation reduce the rate of bladder injury by seven times. Further study is required to confirm the real benefit of this measure.

5.5 POSTOPERATIVE SIGNS, DIAGNOSIS AND MANAGEMENT

In a retrospective study by Salman et al, 3 of 81 patients with bladder injuries were diagnosed postoperatively due to symptoms involving; pain and distension of the abdomen, free intraperitoneal fluid visualized on ultrasound, increased creatinine values, or nausea. (3, 24) Al-Shahrani et al also report that two cases were identified postoperatively due to severe hematuria in the catheter bag. (11) Because most bladder injuries are diagnosed intraoperatively, there is sparse literature regarding post-operative management and modality of choice for these injuries.

5.6 PROGNOSIS

Adequately handled bladder injuries, are not associated with long-term complications. (5, 9, 11) Short-term complications related to urinary bladder injuries are extended operation time, longer hospital stay, longer indwelling catheterization, pain and infection. (7) If bladder injuries are not recognized during CS, long-term complications like vesicovaginal fistula, vesicouterine fistula and urinary ascites may occur. (3, 5, 11) Safrai et al therefore suggest that obstetricians should have a low threshold to confirm bladder unification intraoperatively. (7) Salman et al propose that some of the patients can benefit from a follow-up cystography to evaluate bladder intactness after
repair. (3) However, Salman et al highlight that they cannot provide any criteria for which patients who should be advised to have a cystography, and the clinical impact on the patients. Saaqib et al suggest to follow the patient after CS to make sure they do not have voiding problems like infection, dysuria, frequency, urgency, urethral incontinence and retention. (23)
6. URETER INJURIES

Figure 7: Illustration of the bladder and ureters. Available from https://smart.servier.com/smart_image/bladder/ (Obtained with permission: 21.12.21).

6.1 INCIDENCE

The overall incidence of injuries to the ureters during CS is low in the reviewed literature. In a study by Rahman et al, no ureteric injury is reported in a 25-year period (1983-2007). (8) In a single-center, retrospective cohort study spanning 14 years by Safrai et al, the incidence is presented to be 0.06%. (7) Eisenkop et al report an incidence of 0.09%, while Lo et al report an incidence of 0.11%.(9, 20) All incidents found in reviewed literature are listed in figure 9.
6.2 RISK FACTORS

![Diagram of risk factors]

Figure 8: Overview of potential risk factors associated with ureter injuries.

Many studies show that “blind” hemostatic sutures in an attempt to secure hemostasis is the most common circumstance of ureter injury. (9, 17, 18, 20, 22) Whenever a suture is placed over the ureter, removal is usually curative if immediately handled. Ureteric stenting is sometimes performed to promote healing if the bladder injury involves the ureteral orifices and trigonal area. (7, 12) The cause of the bleeding, is usually an extension of the hysterotomy into the broad ligament or vagina. (6, 9) Eisenkop et al suggest to always confirm the ureteral integrity whenever an uncontrolled extension of the hysterotomy occurs. (9) Safrai et al also report that ureter injuries are more likely to occur during the late second stage of labor. The larger cervix dilatation and the lower positioned fetal head can cause substantial thinning of the tissue, which can increase the risk of an uncontrolled hysterotomy extension. (7)

Previous pelvic surgery or previous CS can distort the pelvic anatomy and cause difficulties during surgery. (25) This is due to the formation of adhesions. Gilani et al present that these patients can have great benefit from the involvement of experienced personnel, precise planning, and possibly imaging to assess the anatomy before surgery. (25) Injuries to the ureters are
reported to happen more frequently during emergency CS. (7, 26) In a study by Lo et al, all ureter injuries happened during emergency CS. (20) Hands-on training is recommended. (26)

6.3 TYPE AND LOCALIZATION OF DAMAGE
The type of injuries to the ureters varies from ligation of the ureters after placement of hemostatic sutures, to more serious injuries like partial or complete transections of the ureters after an extension of the hysterotomy. (9) The distal part of the ureter is the most frequent localization of injury. (22) Some studies show that the left ureter is more often damaged than the right. (20) Possible explanatory models are the positioning of the surgeon in relation to the patient during the procedure, or the natural dextrorotation of the uterus, which places the left ureter more anteriorly and at risk for injury. (20)

6.4 INTRAOPERATIVE SIGNS, DIAGNOSIS, AND MANAGEMENT
An intraoperative diagnosis of damage to the ureters requires knowledge about the most frequent risk factors, especially because direct inspection of the ureters is challenging (7, 18) Thus injuries to the ureters are often diagnosed postoperatively. (17) Whenever bladder dissection is convoluted, it is advisable to confirm the intactness of the urinary tract. (9) Eisenkop et al suggest to evaluate ureteral integrity whenever there is an extension of the hysterotomy towards the broad ligament or the vagina. (9) This can be done by cystoscopy with intravenous injection of indigo carmine to directly observe the discharge of urine from the ureteral orifices, or to perform bilateral ureteral catheterization. (7, 9, 18) If the efflux from the ureteral orifices is absent, it is further recommended to perform a retrograde intravenous pyelogram. (7, 9, 18) Immediate intraoperative repair is reported to be simpler and is correlated with the best prognosis. (27) Safrai et al report that 45% of the ureter injuries were diagnosed intraoperatively, and by cystoscopy in 80% of the incidents. (7) Eisenkop et al claim that injection of indigo carmine might have saved 4 of 7 injuries to the ureters from the inconvenience of a postoperative diagnosis. (9) On the other hand, Shen et al report that these methods are both time-consuming and invasive and that it requires experienced personnel to secure correct execution. (28) They suggest to perform an intraoperative ultrasound to depict the ureteral jets, and presents this as an
easy, effective and safer method. The study does however not examine patients with ureteral damage, and they therefore emphasize the need for further investigation. (28)

6.5 POSTOPERATIVE SIGNS, DIAGNOSIS, AND MANAGEMENT
In a retrospective review by Lo et al, all injuries to the ureters were diagnosed postoperatively. (20) Three cases presented with acute abdominal pain and were immediately admitted to surgery. (20) Other acute symptoms might be flank pain, nausea, unexplained fever, oliguria and hematuria. (6, 20, 24) In the three other cases, the patients had developed ureterouterine fistulas, and presented with watery discharge from the vagina.(20) The diagnoses were confirmed by renal sonography, intravenous pyelogram and abdominal computer tomography (CT). (12, 20, 29) Hydronephrosis and intraperitoneal free fluid can be seen on ultrasound. (17, 20, 22) Safrai et al recommend CT-urography as the first modality of choice if symptoms of ureteral injury arise post-operatively. (7) Tai et al also support this suggestion because a CT-cystogram can reveal contrast extravasation from even the smallest injuries, that might not be visible in retrograde pyelography. (24)

6.6 PROGNOSIS
Ureter injuries are correlated with prolonged hospital stay, the need for secondary operative interventions and potential renal damage. (29) When injuries to the ureters are diagnosed postoperatively, the time of management correlated to prognosis is controversial. (20) It is uncertain if the best outcome is correlated with an early or delayed repair. Joodi et al highlight that perioperative management can reduce the morbidity, expenses and the need for a second operative intervention. (9, 12) Safrai et al state that the timing is essential. In their study, the prognosis was less favorable for the patients with a late postoperative diagnosis. (7)
7. DISCUSSION

7.1 INCIDENCE
Injuries to the bladder and the ureters during CS occur infrequently. The incidence of injuries to the urinary tract throughout reviewed literature varies between 0.05% (4) and 0.47% (3) for bladder injuries. While the incidence of ureter injuries varies between 0 (8) to 0.11% (20). Even though these incidents happen infrequently, obstetricians need to obtain proper knowledge about prevention, diagnosis and management when they occur. Especially since intraoperative care is correlated with a satisfactory prognosis and no long-term complications. (5) Early recognition and repair of damage are important prognostic factors. (4, 5, 8, 9, 17, 18, 20)

7.2 RISK FACTORS
Reviewed literature proposes that there are some statistically significant risk factors related to lower urinary tract injuries, and that attention and awareness around these can be useful preventative measures. The incidence of injuries to the urinary tract depends on risk factors related to both the patient and the surgeon.

The literature mostly agrees that previous CS and the presence of adhesions are important risk factors associated with injuries to the urinary tract during CS. (3-5, 8-14) Many authors highlight that adhesions between the bladder and lower uterine segment can complicate the opening of the peritoneal cavity and the bladder flap. This may further lead to bladder injuries. (8, 9) Adhesions can also distort the normal anatomy, and thus cause difficulties during dissection. (25) Authors discuss whether the incidence of injuries to the urinary tract is higher in elective or emergency CS. It is suggested that women who have elective CS are more likely to be older and multiparous, and also have had prior CS with subsequent formation of adhesions. (5, 8, 10, 13, 15) Those who conclude that emergencies amount for most of the injuries, refer to the stressful circumstances of this event, and the potential lack of sufficient preparation of the patients. (10, 11, 17, 18, 20) A full bladder imposes a higher risk for accidental cystotomy, and haste during the operation can increase the risk of careless dissection and unintended hysterotomy extensions.
Prior CS is a possible cause for the formation of adhesive disease and is a common indication for repeat CS. Whenever women request elective CS, the potential elevated risk of injuries to the urinary tract should be part of the discussion. (5, 8, 13)

Some studies show that injuries happen more frequently whenever CS is executed by inexperienced obstetricians. (8, 17) Therefore; guidance by experienced obstetricians is key in difficult situations, and supervision must be available at all times. (4, 17) Instruction and hands-on training are important to prevent individual and non-experienced based decisions in urgent situations.

Other risk factors for bladder injury have been suggested, but the conclusions are inconsistent throughout reviewed literature. For instance, the following risk factors are discussed; Transfusion of blood, older women, CS during second stage, unsuccessful vacuum delivery prior to CS, adhesions between the bladder and the uterus, extension of the hysterotomy and placenta previa and/or accreta. (11, 15, 30)

The literature concerning ureter injuries are even more sparse. The risk factors for ureter injuries are often coincident with those for bladder injuries. Whenever bladder damage is confirmed, one should always consider the intactness of the ureters. (7)(9) However, the most addressed risk factor regarding ureter injuries throughout reviewed literature are blind hemostatic sutures in an attempt to end an uncontrolled hemorrhage. (9, 17, 18, 20, 22) The bleeding is usually caused by an unintended hysterotomy extension. (7) During the second stage of labor, there is a higher cervix dilatation and the fetal head is deeper engaged in the pelvis. (19) Consequently, a substantial thinning of the tissue can appear, and increase the risk of a hysterotomy extension. (7) Previous surgery or CS, emergency situations and the experience of the obstetrician also appear to play important roles in the occurrence of ureter injuries.

### 7.3 Diagnostic Modalities

Injuries to the bladder are usually diagnosed intraoperatively, while injuries to the ureters are often missed during surgery. Most authors agree that direct inspection is the most reliable method to expose injuries to the bladder during surgery. (5, 8, 11, 15) If there is any doubt about the intactness of the bladder, they consistently suggest to instill methylene blue or indigo carmine in
the Foley catheter. (5, 7, 8, 11) If the damage involves the posterior wall or trigone, or if bladder dissection appears complicated, Safrai suggest to confirm the integrity of the ureters. (7) The most recommended method is cystoscopy with intravenous injection of indigo carmine to observe the discharge from the orifices of the ureters, or to perform bilateral ureteral catheterization. (7, 9, 18) Whenever there is observed an incomplete discharge from the ureteral orifices, some authors suggest to execute a retrograde intravenous pyelogram to evaluate the patency of the ureters. (7, 9, 18) If suspicion for ureter injuries is raised postoperatively, literature suggests to exclude the presence of injury by renal ultrasound, intravenous pyelogram and abdominal CT scans. (12, 20, 29)

7.4 LIMITATIONS OF THE STUDY
The rarity of these events explains the limited number of studies. The sparse amount of available literature and cases make it difficult to exclude articles based on reliability. There are no randomized controlled trials or prospective studies, only retrospective cohort and case control studies with the limitations that involve. Even though a lot of studies report data over many years, the number of events in each study remains low. In addition to the rareness of these events, there are other weaknesses in the reviewed studies. For instance, some suggest that injuries to the urinary tract might be underreported in medical records. Another concern is the inconsistent definition of bladder injury. Sometimes the author separates between partial and full-bladder injury, and other times the type of injury lack a definition. Some studies only review patients who required urologic interventions, while other include small lacerations. The inclusion criteria of patients are not always clearly identified. The true incidence is therefore difficult to ascertain.

Research on rare events can be problematic. It is difficult to consider whether conclusions are significant or just coincidental, and to further evaluate what might be the best possible methods of action. (22). Achieving individual experience on the management of these injuries are also challenging. The limited number of studies, number of patients and the overall low quality of studies makes it difficult to determine guiding principles for proper clinical approach based on statistically significant conclusions. Further research is needed.
8. CONCLUSION

Throughout recent times, the rising number of CS worldwide has brought attention to the potential of an increased occurrence of rare adverse events. Some studies indicate that repeat CS change the risk profile for injuries to the urinary tract through the formation of adhesions. It is important to counsel women who request CS about these potential consequences. Obstetricians should be cognizant of risk factors, symptoms, and diagnostic modalities of choice whenever suspicion for injuries to the urinary tract is raised. They should also aim at an intraoperative, deliberate and targeted repair. An immediate action reduces the risk of severe physical and psychosocial consequences.
### Table of Reviewed Quantitative Studies

<table>
<thead>
<tr>
<th>First author</th>
<th>Year of publication</th>
<th>Study-design</th>
<th>Period</th>
<th>Type of injury</th>
<th>Incidence= n/N</th>
<th>Country</th>
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<tbody>
<tr>
<td><strong>Salman (3)</strong></td>
<td>2017</td>
<td>Retrospective, Case series</td>
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<td><strong>Naicker (4)</strong></td>
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<td>Ureter injury:</td>
<td>1/N*</td>
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<tr>
<td><strong>Gungorduk (5)</strong></td>
<td>2010</td>
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<td>January 1995-September 2009</td>
<td>Bladder injury:</td>
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<td><strong>Safrai (7)</strong></td>
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<td>Bladder injury:</td>
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<td>Study Design</td>
<td>Time Period</td>
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* = Total number CS not given in text

Figure 9: Table of reviewed studies.
10. REFERENCES


