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Systematic Review

Urinary tract infection is associated with 2.4-fold increased risk of surgical site infection in hip fracture surgery: systematic review and meta-analysis

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S U M M A R Y

Background: There is no consensus regarding whether urinary tract infection (UTI) should be screened for or treated in hip fracture patients.

Aim: To assess the relationship between perioperative UTI and surgical site infection (SSI) in hip fracture patients, and the relationship between urinary catheterization and SSI in these patients.

Methods: PubMed, Embase, CINAHL and Cochrane Library were searched to identify studies that evaluated the relationship between perioperative UTI and SSI and/or between urinary catheterization and SSI. Articles were included if they used the term UTI or specified UTI as symptomatic bacteriuria.

Findings: A total of 4139 records were identified, with eight studies included. Meta-analysis of seven studies which evaluated perioperative UTI and SSI showed an SSI rate of 7.1% (95% confidence interval (CI): 3.8–13.2) among 1217 patients with UTI vs 2.4% (95% CI: 1.0–5.7) in 36,514 patients without UTI (OR: 2.41; 95% CI: 1.67–3.46; $P < 0.001$). In three studies which specifically defined UTI as symptomatic bacteriuria, the SSI rate among UTI patients was 5.7% (95% CI: 4.0–8.1) vs 1.1% (95% CI: 0.2–5.2) in those without UTI (OR: 3.00; 95% CI: 0.55–16.26; $P = 0.20$). One study evaluated urinary catheterization and SSI.

Conclusion: Perioperative UTI is associated with a higher risk of SSI among hip fracture patients but the evidence is limited by the heterogeneity in the definition of UTI. We recommend considering the possibility of perioperative UTI in hip fracture patients, with treatment administered as necessary to reduce SSI rates.

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Introduction

Surgical site infection (SSI) can be a devastating complication in patients with hip fracture, with a reported one-year

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mortality rate in those with SSI of around 50%, compared with around 30% in those without SSI [1]. The 2021–2022 surveillance report of the UK Health Security Agency showed that, among NHS hospitals in England, the SSI rate in total hip replacement surgery for acute trauma and chronic elective indications was 0.5%, whereas the SSI rate of repair neck of femur fracture surgery that included hip hemiarthroplasty and fracture fixation was 0.8% [2]. The SSI of hip fracture patients treated with hemiarthroplasty was reported by research studies as 3–10% compared with about 1% in elective hip arthroplasty patients [3–6]. With about 76,000 hip fractures occurring annually in the UK, SSIs could impact a large group of patients.

According to the 2021–2022 UK Health Security Agency surveillance report, across surgical specialties, Enterobacterales were the most prevalent causative organism for SSIs with an increasing 10-year trend [2]. The most common Enterobacterales species was *Escherichia coli*. Enterobacterales SSIs accounted for 18.3% of superficial and 20.3% of deep infections following hip replacement surgery, and 55% of deep polymicrobial infections following repair neck of femur fracture surgery involved a Gram-negative organism. As Enterobacterales are the main causative organisms in urinary tract infection (UTI), there is concern that UTI may be linked to SSI following hip fracture surgery [7].

The screening for and management of UTI in patients having elective hip arthroplasty is well studied and it is widely accepted that symptomatic bacteriuria should be treated and elective surgery postponed [8]. Asymptomatic bacteriuria in elective arthroplasty patients is not routinely tested or treated because antibiotic treatment for preoperative asymptomatic bacteriuria has not been shown to reduce any risk for SSI, and because infective agents isolated from prosthetic joint infection tend to differ from those isolated in the urine [9]. However, the relation between UTI and SSI in hip fracture patients is less well understood. Currently, there is no consensus regarding whether UTI should be screened for or treated in patients with hip fractures. Hip fracture patients are often older and with more comorbidities as compared to those having elective hip surgery, which make them more susceptible to the effects of SSI [10,11]. Although elective arthroplasty could be delayed in the presence of symptomatic bacteriuria, hip fractures require urgent surgical intervention, preferably within 36 h from injury, as longer delays are associated with a higher mortality rate [12,13]. Hence, it is not feasible to wait for urine culture results and the clearance of UTI in hip fracture patients. Besides, UTI could arise after the hip fracture surgery.

Urinary catheterization is frequently placed in hip fracture patients to prevent or treat urinary retention, accommodate patients' limited mobility, and facilitate the measurement of urine output. Urinary catheterization is a risk factor for UTI as the catheter may act as a nidus for bacteria to settle on, but there is no consensus regarding the association of urinary catheterization (inserted before the fracture or after the fracture) with the risk for SSI among hip fracture patients [14].

In view of the above, this systematic review and meta-analysis aimed to assess, first, the relationship between perioperative UTI and SSI in hip fracture patients and, second, the relationship between urinary catheterization and SSI in such patients. It was hypothesized that UTI and urinary catheterization are associated with a higher SSI risk.

Methods

This systematic review was performed according to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) updated guideline in 2020 [15]. The protocol was prospectively registered with PROSPERO (CRD42021273563).

Search strategy

Literature search was performed by two researchers independently in PubMed, Embase, CINAHL, and Cochrane Library databases from their respective inceptions to January 11th, 2022 with no restriction on language. The search commands adopted included: (hip AND fracture AND urinary), (femur AND fracture AND urinary) and (femoral AND fracture AND urinary). References in selected articles found in searches were manually reviewed also to identify any articles missed in the primary search.

Studies on hip fracture patients treated surgically that evaluated the relationship between perioperative UTI and SSI and/or the relationship between urinary catheterization (duration or number of times) and SSI were included. For articles to be included they had to refer to the term UTI or to specify UTI as symptomatic bacteriuria. Exclusion criteria were: (1) studies reporting on elective surgery for non-fracture patients (e.g. osteoarthritis); (2) studies reporting on asymptomatic bacteriuria; (3) systematic reviews/meta-analyses; (4) case series reporting <10 cases; and (5) editorials or commentaries.

Study selection

Two researchers (K.F.K.S. and J.X.Y.L.) independently screened articles by titles and abstracts and then reviewed the full texts to select eligible articles. Disagreement on the selection of articles was settled by discussion between the two researchers and, if necessary, by arbitration by the senior author.

Data extraction

Data were extracted according to a pre-designed proforma, with items including study design, sample size, sex ratio, mean age, patient inclusion and exclusion criteria, surgical intervention, follow-up period, definition and event rate of SSI, definition and event rate of UTI (if any), number of times and time length of urinary catheterization (if any), event rates of SSI in patients with and without UTI (if any), event rates of SSI in patients with and without urinary catheterization (if any), and culture results of SSI and UTI (if any). The risk of bias was assessed with the Newcastle–Ottawa Scale for observational studies.

Statistical analysis

Statistical analysis was performed with R ('meta' and 'metafor' packages), including a meta-analysis to provide an SSI rate and an odds ratio (OR) with confidence interval (CI) calculated, with the examination on the heterogeneity of studies. Meta-analysis was performed with the random effects model due to the diversity of patient populations among selected articles. Publication bias was assessed by inspection of funnel plots.

Results

The initial literature search produced 4139 records. After removal of duplicated records, screening by title and abstract, and full-text review, seven studies, reporting on a total of 37,731 patients were included which evaluated the relationship between perioperative UTI and SSI (Figure 1). These compared SSI rates between 1217 hip fracture patients with UTI vs 36,514 without UTI [16–22]. However, these studies vary on their definition of UTI and on the inclusion of clinical symptoms for the diagnosis of UTI to be made (Table I). Among these studies, three studies reporting on 1303 patients clearly defined UTI as symptomatic bacteriuria [17–19].

The quality of all included studies was evaluated according to Newcastle–Ottawa Scale (NOS) (Table II).

Among all studies included, the SSI rate among UTI patients was 7.1% (95% CI: 3.8–13.2; heterogeneity: $\chi^2 = 43.11$ ($P < 0.0001$); $I^2 = 86.1\%$; $\tau^2 = 0.4878$) vs 2.4% (95% CI: 1.0–5.7; heterogeneity: $\chi^2 = 104.40$ ($P < 0.0001$); $I^2 = 94.3\%$; $\tau^2 = 1.1757$) in those with no UTI (OR: 2.41; 95% CI: 1.67–3.46 ($P < 0.01$); heterogeneity: $\chi^2 = 8.39$ ($P = 0.21$); $I^2 = 25\%$; $\tau^2 = 0.06$) (Table III, Figure 2).

In the three studies which specifically defined UTI as symptomatic bacteriuria, the SSI rate among UTI patients was 5.7% (95% CI: 4.0–8.1; heterogeneity: $\chi^2 = 2.42$ ($P = 0.30$); $I^2 = 17.3\%$; $\tau^2 < 0.0001$) vs 1.1% (95% CI: 0.2–5.2; heterogeneity: $\chi^2 = 13.16$ ($P = 0.0014$); $I^2 = 84.8\%$; $\tau^2 = 1.4930$) in those with

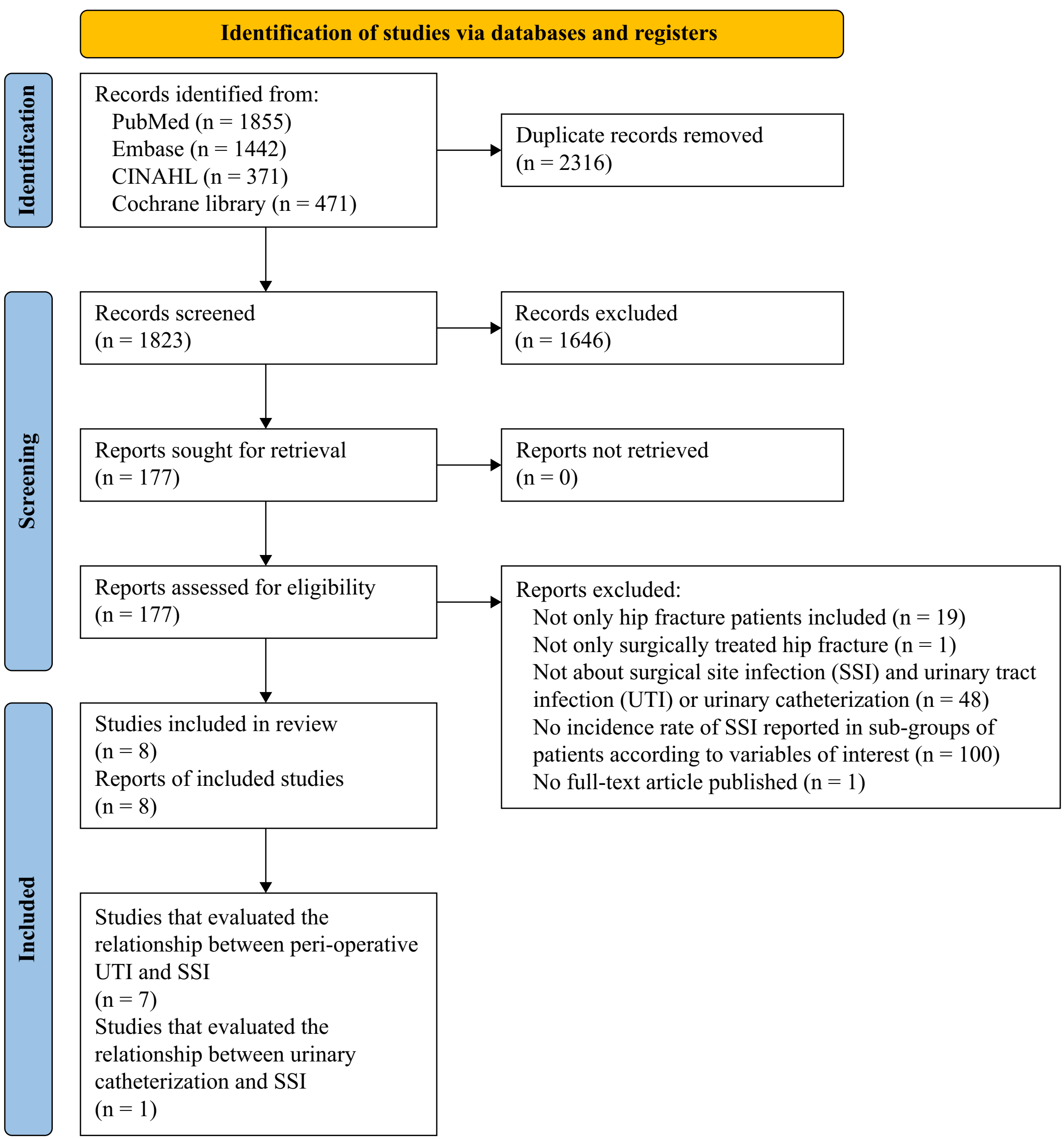

Figure 1. PRISMA flow diagram 2020.

Table I
Characteristics of included studies reporting on the relationship between UTI and SSI rates

Study	Design, centre, duration, country	Sample size	Age (years), mean (SD), unless otherwise specified	Sex	Inclusion criteria, in addition to traumatic hip fracture treated surgically	Exclusion criteria, in addition to not meeting inclusion criteria	Surgical modalities	Definition of 'UTI' or 'symptomatic bacteriuria' (time of test/diagnosis)	Definition of SSI (timeframe of diagnosis)	Antibiotics prophylaxis for surgery and antibiotics for UTI	Incidence of SSI among UTI patients	Incidence of SSI among non-UTI patients
Craxford *et al.* [16]	Retrospective cohort study, single centre, 11 years (Aug 2007–Aug 2018), UK	3966	Among SSI: 82.20 (10.06) Among no SSI: 82.45 (8.89)	Among SSI: M: 20 (29.0%), F: 69 (71.0%) Among no SSI: M: 1118 (28.7%), F: 2779 (71.3%)	Hemiarthroplasty	Revision surgery for periprosethetic fracture or dislocation	HA	Unspecified definition of 'UTI' (pre- and postoperative)	CDC criteria (2008) (12 months)	Unspecified. For most patients, gentamicin-containing cement was used	17/444 (3.82%)	52/3522 (1.48%)
Crouser *et al.* [17]	Retrospective cohort study of database (multi-centre), 2 years (2015–2016), USA	31,621	65–79 years: 10,388 80–89 years: 13,948 ≥90 years: 7285	M: 9171 (29.0%) F: 22,450 (71.0%)	–	/	HA, THR, ORIF	Characteristic symptoms of UTI present, but not essentially with bacteriuria shown microbiologically[a] (at the time of surgery)	CDC criteria (30 days)	Unspecified	24/410 (5.85%)	1159/31,211 (3.71%)
Langenhan *et al.* [18]: only group 2 of this study	Retrospective cohort study, single centre, 31 months (Sep 2014–Mar 2017) for Group 2, Germany	441 in Group 2	83.93 (7.70) for Group 2	Group 2: M: 120 (27.2%), F: 321 (72.8%)	Age ≥65 years	Deep surgical site infection after revision surgery	HA, THR, ORIF	Bacteriuria shown microbiologically, with data about the subgroup of patients with symptomatic bacteriuria[b] (preoperative at admission)	Early deep SSI (pathogens detected in cultures of synovial fluid or peri-implant tissue) (3 months)	Cefuroxime at time of surgery + preoperative ciprofloxacin for few days if bacteriuria	0/141 (0.00%) Among those with symptomatic bacteriuria: 0/77 (0.00%)	2/300 (0.67%) Among those without symptomatic bacteriuria: 2/364 (0.55%)
Bliemel *et al.* [19]	Prospective cohort, single centre, 2.5 years (Apr 2009–Sep 2011), Germany	402	81 (8)	M: 109 (27.1%) F: 293 (72.9%)	Age ≥60 years	Polytrauma, malignancy-related fracture	HA, THR, ORIF	Characteristic symptoms of UTI present, but not essentially with bacteriuria shown microbiologically[a] (all patients were catherized at admission) (whenever symptoms of UTI appear)	Clinical, laboratory and sonographic examinations (unspecified time)	Yes, unspecified antibiotics. UTI was treated according to local guidelines	6/97 (6.19%)	1/305 (0.33%)

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no UTI (OR: 3.00 (95% CI:

Table I (*continued*)

Study	Design, centre, duration, country	Sample size	Age (years), mean (SD), unless otherwise specified	Sex	Inclusion criteria, in addition to traumatic hip fracture treated surgically	Exclusion criteria, in addition to not meeting inclusion criteria	Surgical modalities	Definition of 'UTI' or 'symptomatic bacteriuria' (time of test/diagnosis)	Definition of SSI (timeframe of diagnosis)	Antibiotics prophylaxis for surgery and antibiotics for UTI	Incidence of SSI among UTI patients	Incidence of SSI among non-UTI patients
Yassa *et al*. [20]	Retrospective cohort study, single centre, 1 year (unspecified time), UK	460	80.9	M: 124 (27%) F: 336 (73%)	/	/	HA, THR, ORIF	'UTI' was defined as bacteriuria shown by positive dipstick, but their database did not specify whether 'UTI' cases were symptomatic or not[c] (routine dipstick at admission)	Unspecified (unspecified time)	Single dose of flucloxacillin and gentamicin at time of surgery + postop another dose of flucloxacillin. UTI was treated with trimethoprim for 3 days	23/99 (23.2%)	34/361 (9.42%)
Capdevila *et al*. [21]	Retrospective cohort study, single centre, 16 months (Jun 2012–Sep 2013), Spain	657	83.1 (10.4)	M: 188 (28.6%) F: 469 (71.4%)	/	/	HA, THR, ORIF	Unspecified definition of 'UTI'	Superficial and deep SSI, CDC criteria (1999) (1 year)	Cefuroxime and teicoplanin at time of surgery. For cemented prosthesis, cement without antibiotics was used.	4/78 (5.13%)	9/579 (1.55%)
Westberg *et al*. [22]	Retrospective cohort study, single centre, 2 years (2018–2019), Norway	184	With PJI: 79 (9) Without PJI: 81 (10)	With PJI: M: 6 (35%), F: 11 (65%) Without PJI: M: 52 (31%), F: 115 (69%)	Arthroplasty	Patients from outside the hospital catchment area, or pathological fractures	HA, THR	Unspecified definition of 'UTI'	PJI defined as deep SSI of CDC criteria (1999) and Tsukayama's criteria for timing for early infection (4 weeks)	Cephalotin at time of surgery and 3 more doses over postoperative 24 h. For most patients, gentamicin-containing cement was used	2/12 (16.7%)	15/172 (8.02%)

UTI, urinary tract infection; SSI, surgical site infection; THR, total hip replacement; HA, hemiarthroplasty; ORIF, open reduction internal fixation; PJI, prosthetic joint infection; APJI, acute prosthetic joint infection.

[a] Diagnosis of 'UTI' in these studies required the presence of characteristic UTI symptom(s) and required either positive culture growth OR positive urine analysis nitrite and/or leucocytes.

[b] Diagnosis of 'bacteriuria' required positive urine sediment and microscopy analysis results; diagnosis of 'UTI' required 'bacteriuria' with characteristic UTI symptoms.

[c] Diagnosis of 'UTI' required positive urine dipstick and did not require microbiological evidence or characteristic UTI symptoms.

Table II
The Newcastle–Ottawa scale score of included studies

Cohort study	Representativeness of the exposed cohort	Selection of the non-exposed cohort	Ascertainment of exposure	Demonstration that outcome of interest was not present at start of study	Comparability of cohorts on the basis of the design or analysis		Assessment of outcome	Follow-up long enough for outcomes to occur	Adequacy of follow-up of cohorts	Total
Craxford *et al.* [16]	1	1	1	1	1	1	1	1	1	9/9
Crouser *et al.* [17]	1	1	1	1	0	0	1	1	1	7/9
Langenhan *et al.* [18]	1	1	1	1	0	0	1	1	1	7/9
Bliemel *et al.* [19]	1	1	1	1	1	1	1	1	1	9/9
Yassa *et al.* [20]	1	1	1	1	0	0	1	1	1	7/9
Capdevila *et al.* [21]	1	1	1	1	1	1	1	1	1	9/9
Westberg *et al.* [22]	1	1	1	1	1	1	1	1	1	9/9
Case–control study	Adequate case definition	Representativeness of the cases	Selection of controls	Definition of controls	Comparability of cases and controls on the basis of the design or analysis		Ascertainment of exposure	Same method of ascertainment for cases and controls	Non-response rate	Total
Cumming and Parker [23]	1	1	0	1	1	0	1	1	0	6/9

Table III
SSI rates among UTI patients and among non-UTI patients

Definition of UTI	No. of studies	UTI			No UTI		
		No. of patients	SSI rate (95% CI)	Heterogeneity: χ^2 (*P*-value), I^2, τ^2	No. of patients	SSI rate (95% CI)	Heterogeneity: χ^2 (*P*-value), I^2, τ^2
Studies referring to the term 'UTI' or to the term 'symptomatic bacteriuria'	7	1217	7.1% (3.8–13.2)	43.11 ($P < 0.0001$), 86.1%, 0.4878	36,514	2.4% (1.0–5.7)	104.40 ($P < 0.0001$), 94.3%, 1.1757
Studies referring to 'symptomatic bacteriuria'	3	584	5.7% (4.0–8.1)	2.42 ($P = 0.30$), 17.3%, <0.0001	31,880	1.1% (0.2–5.2)	13.16 ($P = 0.0014$), 84.8%, 1.4930

SSI, surgical site infection; UTI, urinary tract infection; CI, confidence interval.

0.55–16.26 ($P = 0.20$); heterogeneity: $\chi^2 = 5.35$ ($P = 0.07$); $I^2 = 63\%$; $\tau^2 = 1.39$) (Table IV, Figure 3).

Only one study was identified which evaluated the relationship between urinary catheterization and SSI in hip fracture patients (Table V), so meta-analysis was not performed with regard to this evaluation. In that study, Cumming *et al.* showed that deep wound infection in hip fracture patients was associated with more than two catheterizations and long-term catheters (>21 days of catheterization or being discharged from hospital with a catheter *in situ*) [23].

Discussion

The current meta-analysis showed a high rate of SSI among hip fracture patients who have perioperative UTI, estimated at 7.1%, while the risk for SSI among UTI patients was estimated at 2.4-fold higher compared with non-UTI patients.

Several mechanisms have been postulated to explain the relationship between UTI and SSI. Understanding such mechanisms is vital as it may shed further light on the pathogenesis of SSI and identify a possible target for intervention to reduce SSI rates and thus mortality in hip fracture patients [1]. The relation between UTI and SSI may be due to direct contamination of the wound by infected urine. External surgical wound contamination by urine micro-organisms could also be a source of SSI in hip fracture patients. Reduced mobility and cognitive status are also risk factors for UTI [24]. Dementia, cognitive impairment, and delirium are common among hip fracture patients, which may lead to contamination of the surgical wound by unintentional physical contact with urine [25,26].

Contamination may also occur via a haematogenous route from the urinary tract to the surgical wound. It was previously shown that haematoma at the site of a hip fracture commonly contained bacteria even before surgery and the presence of Gram-negative bacilli in the haematoma was a risk factor for early postoperative prosthetic joint infection [27]. The researchers postulated that this could be due to UTI contaminating the wound via bacterial translocation. Bacterial translocation is a well-recognized phenomenon which refers to the passage of gut microflora from the gastrointestinal tract to other tissues and organs, due to increased intestinal permeability at times of physiological stress and could be the mechanism behind postoperative sepsis after major gastrointestinal surgery [28–30]. A similar process of translocation of uropathogens through the uroepithelium, into the renal interstitium and subsequently into the bloodstream is well studied in UTI, and this process involves the formation of intracellular bacterial communities within uroepithelial cells [31]. There is also limited evidence about bacterial translocation in asymptomatic bacteriuria: in a small animal study, uropathogenic *Escherichia coli* cultured from five asymptomatic bacteriuric humans were seen to form intracellular bacterial communities to cause cystitis in a mouse model [32].

Alternatively, UTI may cause immunosuppression that indirectly leads to a higher risk of SSI [20]. This proposed mechanism of immunosuppression due to UTI may be particularly important in hip fracture patients due to their greater burden of comorbidities. Such a mechanism could explain the mismatch between UTI and SSI culture isolates [16,18,20].

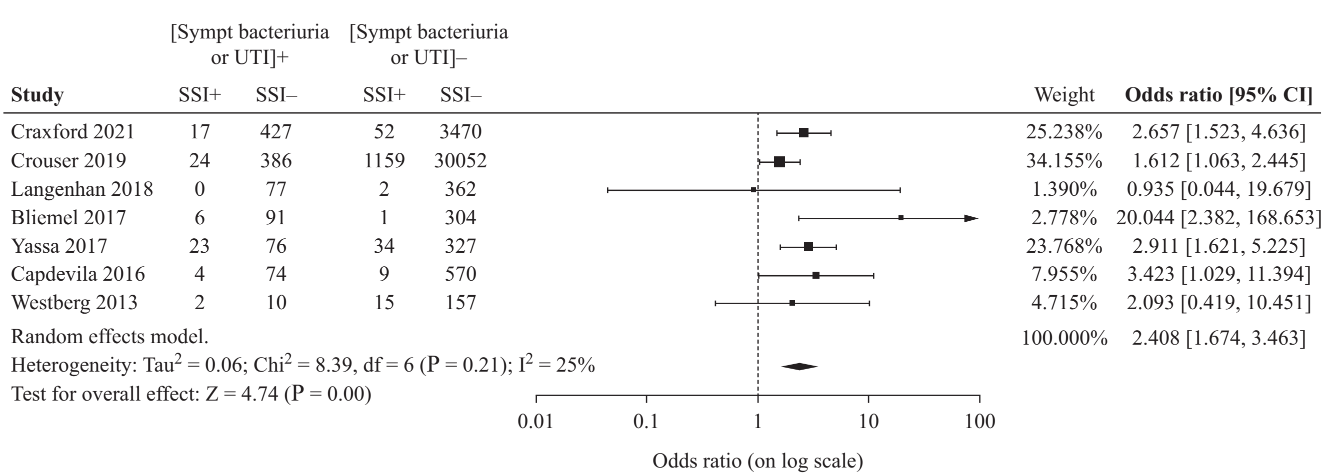

Figure 2. Forest plot of odds ratio for surgical site infection among urinary tract infection patients.

Table IV
Odds ratio for SSI in UTI patients vs non-UTI patients

Definition of UTI	No. of studies	No. of patients	Odds ratio (95% CI), *P*-value	Heterogeneity: χ^2 (*P*-value), I^2, τ^2,
Studies referring to 'UTI' or 'symptomatic bacteriuria'	7	37,731	2.41 (1.67–3.46) $P < 0.01$	8.39 ($P = 0.21$) 25%, 0.06
Studies referring to 'symptomatic bacteriuria'	3	32,444	3.00 (0.55–16.26) $P = 0.20$	5.35 ($P = 0.07$) 63%, 1.39

SSI, surgical site infection; UTI, urinary tract infection; CI, confidence interval.

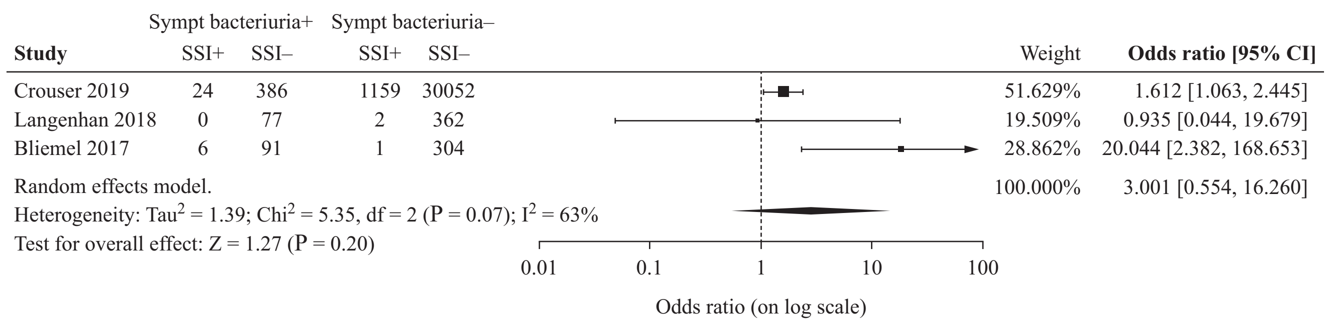

Figure 3. Forest plot of odds ratio for surgical site infection among patients with urinary tract infection specifically defined as symptomatic bacteriuria.

Diagnosis of UTI is challenging, as clinical symptoms and urine culture samples may not be in line. Some patients may experience urinary symptoms but have a negative urine culture, some may have no urinary symptoms but generalized symptoms of infection with a positive or negative urine culture, whereas some may have asymptomatic bacteriuria. Asymptomatic bacteriuria is generally considered a separate entity as compared to UTI as it may simply reflect colonization of the urinary tract, hence articles reporting on asymptomatic bacteriuria were excluded from our analysis.

Although we established a statistical association between UTI and SSI, as the included studies were observational, a causal relationship could not be established. Nevertheless, there is some evidence suggesting that treatment of UTI reduces the SSI rate. Langenhan *et al.* retrospectively collected data in a group of patients who received a single dose of 1.5 g of cefuroxime as preoperative prophylaxis and then prospectively collected data in another group which, in addition to the preoperative cefuroxime, received ciprofloxacin if bacteriuria was found by urine sediment analysis at admission [18]. At three-month follow-up, they showed a deep SSI rate of about 2.1% in the former group but only 0.45% in the latter group 2 ($P = 0.02$). However, it was pointed out that ciprofloxacin might only delay the presentation of SSI to beyond the study's surveillance period, instead of the SSI rate [33,34].

Regarding urinary catheterization, it is a well-established risk factor for UTI, as catheters provide a direct conduit for rectal and peri-urethral microbes to reach the bladder [35]. The National Institute of Clinical Excellence in England defined catheter-associated UTI as the presence of symptoms or signs compatible with UTI in people with a catheter with no other identified source of infection, plus significant levels of bacteria in a catheter or a midstream urine specimen when the catheter has been removed within the previous 48 h [36]. Currently, there is no standardization or consensus among hospitals about the protocol of urinary catheterization regarding antibiotic prophylaxis, duration of catheterization, and procedures of peri-urethral cleansing [37]. In the context of prosthetic joint infection, it has been assumed that catheter insertion could cause local trauma and hence haematogenous spreading of infection to prosthetic joint, but a systematic review on elective knee and hip arthroplasty concluded that there was no evidence for any association between urinary catheterization and an increased risk for prosthetic joint infection [38]. We found only one study investigating the relationship between urinary catheterization and SSI in hip fracture patients, which showed that deep wound infection was associated with more than two catheterizations and with prolonged catheter use (i.e. having >21 days of catheterization or being discharged home with a catheter *in situ*) [23].

Based on our findings and the benefit of treating UTI shown by Langenhan *et al.*, we recommend considering the possibility of perioperative UTI in hip fracture patients with treatment administered as necessary. As the surgical treatment for hip fracture could not be deferred until the definite diagnosis and clearance of UTI, the possibility of UTI in hip fracture patients has to be evaluated early and carefully, without causing any delay to the hip fracture's surgical management.

Evaluating hip fracture patients for UTI may be undertaken with targeted clinical history-taking, clinical examination, and routine urine evaluation before sending off the urine specimen for conventional urine culture in the laboratory. The evaluation on urine could be done by point-of-care tests of UTI, such as semi-automated urine analysers based on the level of colony-forming units/mL and culture-based devices, to speed up the diagnosis [39,40]. In the circumstances where these point-of-care tests are not available, alternatives include inspection of the urine for cloudiness, urine dipstick, and microscopy.

Table V
Characteristics of included studies reporting on the relation between urinary catheterization and SSI rates

Study	Design, centre, duration, country	Sample size	Age (mean (range)	Sex	Inclusion criteria, in addition to traumatic hip fracture treated surgically	Exclusion criteria, in addition to not meeting inclusion criteria	Surgical modalities	Definition of SSI (timeframe of diagnosis)	Antibiotic prophylaxis for surgery and for catheterization	Having urinary catheter perioperatively or within 5 days of surgery	Having more than 2 episodes of urinary catheterization	Long-term catheterization[a]
Cumming and Parker [23]	Retrospective case–control study, single centre, about 10 years (Jun 1994–Sep 2004), UK	3180 patients with hip fracture. 18 patients with deep sepsis, 36 patients in control group	Among SSI: 79.8 (60–94) Among control: 81.9 (47–95)	Among SSI: M: 3 (16.7%), F: 15 (83.3%) Among control: M: 7 (19.4%), F: 2779 (80.6%)	Available case notes. Control group: for each patient with deep wound infection, the next two patients that were admitted with a hip fracture and treated with the same implant	N/A	HA, THR, ORIF	Deep wound infection (used interchangeably with 'deep sepsis'), defined as presence of clinical evidence of infection below the deep fascia, with or without microbiological confirmation (1 year from injury)	Three doses of cefuroxime at the time of surgery and postoperatively. No prophylactic antibiotics as standard on insertion or removal of the catheter.	Deep sepsis: 12/18 (66.7%) No sepsis: 18/36 (50.0%)	Deep sepsis: 6/18 (33.3%) No sepsis: 3/36 (8.33%)	Deep sepsis: 7/18 (38.9%) No sepsis: 3/36 (8.33%)

THR, total hip replacement; HA, hemiarthroplasty; ORIF, open reduction internal fixation.
[a] Long-term catheterization was defined as either catheterization of >21 days, or having a catheter *in situ* when discharged.

The urine specimen could be collected via a urinary catheter, if necessary due to patient's immobility, but the catheter should be removed as early as possible to reduce the risk of SSI associated with catheterization [23]. If point-of-care tests for UTI show positive results, or if the urine is cloudy, or if the dipstick and microscopy are positive, then antibiotics for UTI may be considered and continued until the results of the conventional urine culture in the laboratory become available. In deciding to initiate antibiotic treatment, it must also be considered that patients with reduced cognition may have difficulty expressing themselves when they suffer from UTI symptoms, so UTI could be under-diagnosed [24,41]. However, the consideration of treatment must be balanced against potential side-effects of antibiotics such as causing diarrhoea which could lead to wound contamination.

Regarding urinary catheterization and its relationship to SSI in hip fracture patients, we identified only one relevant article addressing this issue, so we recommend avoiding the risk factors reported in that study. These risk factors were more than two catheterizations and prolonged catheter use (>21 days of catheterization or being discharged from hospital with a catheter *in situ*) [23].

This study has several limitations, so the results should be interpreted with caution. There are differences among included studies, such as population demographics, surgical modalities and definitions or diagnostic criteria of SSI and UTI. Thus, although the odds ratio was statistically significant when comparing SSI rates in UTI and that in non-UTI groups, this did not hold when analysing the three studies that used a specific definition of symptomatic bacteriuria for UTI. Nevertheless, in the latter comparison, there was a clear trend of a higher risk of SSI with UTI (OR: 3.0; 95% CI: 0.55–16.26) and the non-significance may be related to the smaller number of studies available for analysis. Regarding SSI, studies have adopted different definitions and timeframes for diagnosis. In addition, all included studies are observational, with no high-quality randomized controlled trial available. Furthermore, the use of indwelling urinary catheters was not well documented in many studies, so we were unable to assess the relationship between urinary catheterization and SSI.

Future work in the form of high-quality randomized controlled trials comparing the SSI rates between treated and untreated preoperative UTI may provide evidence as to a causal link between the two. Further work on the relationship between urinary catheterization and SSI rates is also warranted. The relation between asymptomatic bacteriuria and SSI rates, which was not examined in this study, also remains to be determined.

In conclusion, our review has revealed an association of perioperative UTI with a higher risk of SSI among hip fracture patients treated surgically, but there is substantial heterogeneity among the available studies examined. Further work is needed to refine the diagnostic criteria of UTI, especially in patients with poor cognitive function, and to determine whether treatment of UTI reduces SSI rates. However, until such high-quality evidence is gathered, given the devastating effects of SSI on hip fracture patients, we recommend considering the possibility of perioperative UTI in this highly vulnerable patient group, with treatment administered as necessary to reduce SSI rates. UTI should also be considered when assessing and comparing SSI rates, either at a local hospital or wider healthcare level.

Author contributions

K.F.K.S.: Article screening and selection, data collection, statistical analysis, writing the original draft, reviewing and editing the manuscript. J.X.Y.L.: Article screening and selection, writing the original draft. C.P.C.: Conceptualization, statistical analysis, reviewing and editing the manuscript, supervision and mentorship. All authors made the final approval of the version to be published and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Conflict of interest statement

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