Med Pregl 2026; LXXIX(1-2): 11-17. Novi Sad: januar-februar.

ORIGINAL STUDIES
ORIGINALNI NAUČNI RADOVI

FIFTEEN-YEAR TRENDS IN GROIN WOUND INFECTION AFTER FEMORAL VASCULAR ACCESS – INCIDENCE, SEVERITY, AND MICROBIOLOGICAL SHIFTS IN A TERTIARY CENTER COHORT

PETNAESTOGODIŠNJI TRENDOVI INFEKCIJE PREPONSKE RANE NAKON FEMORALNOG VASKULARNOG PRISTUPA – INCIDENCIJA, TEŽINA I MIKROBIOLOŠKE PROMENE U KOHORTI TERCIJARNOG CENTRA

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Original study
Originalni naučni rad
UDK 616.1-089.168:616-001.47
https://doi.org/10.2298/MPNS2602011N

Abstract
Introduction. Wound infection after groin incision remains a frequent complication in vascular surgery, yet long-term single-center data on temporal trends, severity distribution, and pathogen shifts are scarce in southeastern Europe. This study describes the 15-year epidemiology of groin wound infection following femoral vascular procedures and examines changes in incidence, wound depth classification, and methicillin-resistant Staphylococcus aureus prevalence. **Material and Methods.** All consecutive groin incisions for femoral arterial access performed at a single tertiary vascular center between January 2010 and December 2024 were reviewed. Wound infection was diagnosed within 90 days using standardized surveillance criteria. Annual rates were calculated and tested for temporal trend. Culture results were analyzed by five-year period. **Results.** Among 8,742 groin incisions, 846 (9.7%) developed a wound infection: 490 superficial (57.9%), 245 deep (29%), and 111 organ/space (13.1%). Annual rates fluctuated between 8.2% and 11.5% without a significant directional trend ($p = 0.284$). The highest unadjusted rate was observed after infrainguinal bypass (13%). Of 724 culture-positive episodes, the methicillin-resistant Staphylococcus aureus proportion rose across three predefined five-year periods, from 8.7% in 2010–2014 to 13.8% in 2015–2019 and 21% in 2020–2024 (p for trend < 0.001), while gram-negative isolates remained relatively stable at 23–26%. **Conclusion.** Groin wound infection affected approximately one out of ten femoral vascular procedures over 15 years with no measurable decline across the observation period. The steady rise in methicillin-resistant Staphylococcus aureus supports institutional review of empirical prophylaxis protocols at centers with similar resistance profiles.
Key words: Surgical Wound Infection; Groin; Vascular Surgical Procedures; Catheterization; Postoperative Complications; Methicillin-Resistant Staphylococcus aureus; Infections; Risk Factors; Epidemiology; Microbiology

Sažetak
Uvod. Infekcija rane nakon preponske incizije ostaje česta komplikacija vaskularne hirurgije, ali su dugoročni jednocentrični podaci o vremenskim trendovima, distribuciji težine i promenama patogena retki u Jugoistočnoj Evropi. Ova studija opisuje 15-godišnju epidemiologiju infekcije preponske rane nakon femoralnih vaskularnih procedura i ispituje promene u incidenciji, klasifikaciji dubine rane i prevalenciji meticilin-rezistentnog *Staphylococcus*-a *aureus*. **Materijal i metode.** Analizirane su sve uzastopne preponske incizije za femoralni arterijski pristup u jednom tercijarnom vaskularnom centru od januara 2010. do decembra 2024. godine. Infekcija rane je dijagnostikovana u roku od 90 dana korišćenjem standardizovanih kriterijuma nadzora. Godišnje stope su izračunate i testirane na vremenski trend. Rezultati kultura su analizirani po petogodišnjim periodima. **Rezultati.** Od 8.742 preponske incizije, 846 (9,7%) je razvilo infekciju rane: 490 površinskih incizionih (57,9%), 245 dubokih (29%) i 111 organ/prostornih (13,1%). Godišnje stope su varirale od 8,2% do 11,5% bez značajnog trenda ($p = 0,284$). Najviša neprilagođena stopa je zabeležena nakon infraingvinalnog bajpasa (13%), praćenog aortobifemoralnom rekonstrukcijom (12%). Od 724 kulturom pozitivne epizode, udeo meticilin-rezistentnog *Staphylococcus*-a *aureus* porastao je sa 8,7% u periodu 2010–2014. na 13,8% u periodu 2015–2019. i 21% u periodu 2020–2024. (p za trend < 0,001), dok su Gram-negativni izolati ostali relativno stabilni na 23–26%. **Zaključak.** Infekcija preponske rane zahvatila je približno jednu od deset femoralnih vaskularnih procedura tokom 15 godina bez merljivog smanjenja tokom perioda posmatranja. Stalni porast meticilin-rezistentnog *Staphylococcus*-a *aureus* podržava institucionalno preispitivanje protokola empirijske profilakse u ustanovama sa sličnim profilom rezistencije.
Ključne reči: infekcija hirurške rane; prepone; vaskularne hirurške procedure; kateterizacija; postoperativne komplikacije; meticilin-rezistentni Staphylococcus aureus; infekcija; faktori rizika; epidemiologija; mikrobiologija

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Abbreviations

SSI	– surgical site infection
MRSA	– methicillin-resistant Staphylococcus aureus
MSSA	– methicillin-susceptible Staphylococcus aureus
EVAR	– endovascular aneurysm repair
GIVE	– Groin wound Infection after Vascular Exposure
NSQIP	– National Surgical Quality Improvement Program
EUCAST	– European Committee on Antimicrobial Susceptibility Testing

Introduction

Groin incision remains a common access route in open and hybrid vascular procedures and continues to be associated with clinically important postoperative wound morbidity [1–4]. Published incidence figures range widely, from below 3% in endovascular series to over 40% in high-risk bypass cohorts, reflecting heterogeneity in case selection, follow-up duration, and diagnostic criteria [3,5].

Local surveillance data may help contextualize institutional wound infection burden, identify procedure groups with higher wound morbidity, and monitor microbiological shifts over time. However, most existing reports originate from multicenter registries with short recruitment windows or from Western European and North American settings [1,2,6]. We identified limited published long-term single-center surveillance data from southeastern European vascular centers, despite regional antimicrobial resistance profiles that may diverge from Western European benchmarks [7,8].

This study had three objectives: first, to characterize the 15-year incidence and severity distribution of groin wound infection after femoral vascular access at a tertiary referral center; second, to examine whether infection rates changed over time; and third, to describe the microbiological spectrum with particular attention to methicillin-resistant Staphylococcus aureus (MRSA) trends.

Material and Methods

Study design and setting

A retrospective observational study was conducted at the sole tertiary vascular unit serving a geographically defined catchment of approximately two million inhabitants. The review covered all consecutive femoral-access vascular procedures performed between January 1, 2010 and December 31, 2024. Clinical, operative, and microbiological records were linked through the institutional hospital information system. Approval was obtained from the Institutional Ethics Committee (Protocol 01-19-103-2/24); individual consent was waived given the retrospective, non-interventional design.

Study population

A total of 12,180 groin and lower-extremity vascular procedures were identified in the operative database. After excluding 2,156 purely percutaneous approaches that did not require a skin incision and a further 1,282 cases with pre-existing wound infection (n = 187), non-femoral arterial access (n = 892), or documentation insufficient for outcome determination (n = 203), the analysis comprised 8,742 evaluable groin incisions in 7,218 individual patients.

Outcome definition

Groin wound infection was classified according to the surveillance definitions of the United States Centers for Disease Control and Prevention: superficial incisional (involving skin and subcutaneous tissue), deep incisional (fascia and muscle), and organ/space (vascular graft or perigraft tissue) [9]. A uniform 90-day surveillance window was applied to all procedures because the majority involved prosthetic material, for which extended follow-up is mandated, and because deep infections characteristically present two to four weeks after the index operation [4,10]. Two vascular surgeons independently adjudicated every case without access to each other's assessment; a third surgeon arbitrated the small proportion of disagreements (4.2%).

Microbiological data

Wound cultures were obtained at the discretion of the treating surgeon whenever clinical infection was suspected. Specimens were processed using standard aerobic and anaerobic protocols. Antibiotic susceptibility was determined by disc diffusion and automated systems according to European Committee on Antimicrobial Susceptibility Testing (EUCAST) breakpoints [11]. MRSA was defined phenotypically by cefoxitin resistance confirmed by molecular testing when available.

Statistical analysis

Categorical variables are expressed as absolute counts and percentages; continuous variables as means with standard deviation or medians with interquartile range where appropriate. Patient-level characteristics (age, sex, diabetes, obesity, chronic kidney disease, smoking, immunosuppression) are reported per individual patient, whereas operative characteristics (procedure type, anesthesia, prosthetic material) are reported per groin incision. Annual infection rates were calculated as the number of events divided by the number of incisions performed in that calendar year, with Wilson 95% confidence intervals. Temporal trends were evaluated with the Cochran–Armitage test for proportions. As a sensitivity analysis, temporal change in infection incidence was additionally modeled using binomial regression with calendar year as an ordinal predictor, reporting the estimated annual change and 95% confidence interval. Changes in pathogen distribution across three predefined five-year strata (2010–2014, 2015–2019, 2020–2024) were compared using χ^2 tests. Procedure-specific and severity subgroup comparisons were descriptive and exploratory; p values from these analyses should be interpreted cautiously. No a priori sample size calculation was performed because the study included all consecutive eligible procedures during the predefined 15-year period. Because a uniform 90-day surveillance window was applied to all procedures regardless of implant status, the reported incidence for non-prosthetic procedures (endarterectomy, groin cutdown) may be higher than in series using a 30-day definition. Direct comparisons with studies applying shorter surveillance windows should therefore be interpreted with caution. Multivariable risk-factor analysis was not performed because the primary aim was descriptive trend characterization; a companion prediction model study from the same cohort has been reported separately (Nikolić et al., submitted). This study is reported in accordance with the STROBE statement for observational cohort studies. Statistical significance was set at a two-sided $p < 0.05$. Analyses were performed in R version 4.3.2.

Results

Patient and procedural characteristics

The 8,742 groin incisions were performed in 7,218 patients with a mean age of 67.4 ± 10.8 years; 65% were men. The most prevalent comorbidities were diabetes mellitus (36%), active smoking (41%), obesity (27%), and chronic kidney disease (21%). Infrainguinal bypass accounted for 32.4% of incisions, followed by femoral endarterectomy (21.6%), aortobifemoral reconstruction (17%), endovascular repair with groin cutdown (15.4%), and other femoral-access procedures (13.6%) **(Table 1).**

Overall incidence and severity

Wound infection was identified in 846 of 8,742 incisions, yielding an overall rate of 9.7% (95% confidence interval 9.1–10.3). Superficial infections constituted the largest category (490 episodes; 57.9%), followed by deep incisional infections (245; 29%) and organ/space involvement (111; 13.1%). The median time from operation to diagnosis was 12 days (interquartile range 7–21) for superficial infections, 19 days (12–32) for deep infections, and 26 days (16–48) for organ/space infections.

Incidence by procedure type

Procedure-specific rates showed substantial variation **(Table 2).** The highest unadjusted infection rate was observed after infrainguinal bypass at 13% (95% confidence interval 11.8–14.3), with a notable proportion of deep and organ/space infections (41%). Aortobifemoral procedures followed at 12% (10.4–13.7). Femoral endarterectomy and endovascular groin cutdown had lower rates of 7.5% and 5.5%, respectively. These procedure-specific differences should be interpreted as unadjusted surveillance findings and not as independent estimates of procedural risk, because bypass patients typically carry a heavier comorbidity burden. The “other femoral access” category, which

Table 1. Baseline characteristics

Characteristic	n or mean	
Total groin incisions	8,742	100
Individual patients	7,218	–
Age, years, mean ± SD	67.4	±10.8
Male sex	4,692	65.0
Diabetes mellitus	2,598	36.0
Active smoking	2,959	41.0
Obesity (body mass index ≥30)	1,949	27.0
Chronic kidney disease	1,516	21.0
Immunosuppressive therapy	505	7.0
Infrainguinal bypass	2,834	32.4
Femoral endarterectomy	1,892	21.6
Aortobifemoral reconstruction	1,486	17.0
EVAR with groin cutdown	1,342	15.4
Other femoral-access procedures	1,188	13.6
General anesthesia	6,367	72.8
Prosthetic material implanted	5,981	68.4

EVAR – endovascular aneurysm repair. Patient-level characteristics (age, sex, comorbidities) are reported per individual patient (n = 7,218); operative characteristics (procedure type, anesthesia, prosthetic material) are reported per groin incision (n = 8,742).

Table 2. Infection rates by procedure and severity

Procedure	n	SSI, n (%)	Superficial incisional	Deep	Organ/space (graft)	
Infrainguinal bypass	2,834	369 (13.0)	216	107	46	11.8–14.3
Aortobifemoral	1,486	178 (12.0)	94	56	28	10.4–13.7
Femoral endarterectomy	1,892	142 (7.5)	90	38	14	6.4–8.8
EVAR cutdown	1,342	74 (5.5)	46	20	8	4.4–6.9
Other femoral access	1,188	83 (7.0)	44	24	15	5.7–8.6
Total	8,742	846 (9.7)	490	245	111	9.1–10.3

95% CI: Wilson method; SSI – surgical site infection

encompassed thrombectomy, embolectomy, and re-operative femoral exposure, accounted for 18.1% organ/space infections, possibly reflecting heterogeneous indications and re-operative tissue disruption.

Temporal trends in overall and severity-specific rates

Annual infection rates ranged from a low of 8.2% in 2014 to a peak of 11.5% in 2017 **(Table 3, Graph 1)**. The Cochran–Armitage test detected no significant directional change over the 15-year observation period ($p = 0.284$). Binomial regression with calendar year as an ordinal predictor estimated an annual change in infection rate of +0.02 percentage points (95% confidence interval –0.12 to +0.16), consistent with the non-significant trend test. When examined by severity category, superficial infections remained the predominant subtype throughout, and the proportion of organ/space infections varied between 10.6% and 13.3% across the three five-year periods (13% in 2010–2014, 10.6% in 2015–2019, and 13.3% in 2020–2024; $p = 0.58$) without a consistent directional trend. The COVID-19 pandemic years (2020–2021) were associated with a transient dip in operative volume but no detectable change in infection rates, consistent with findings from Italian vascular centers [7].

Microbiological spectrum and MRSA trends

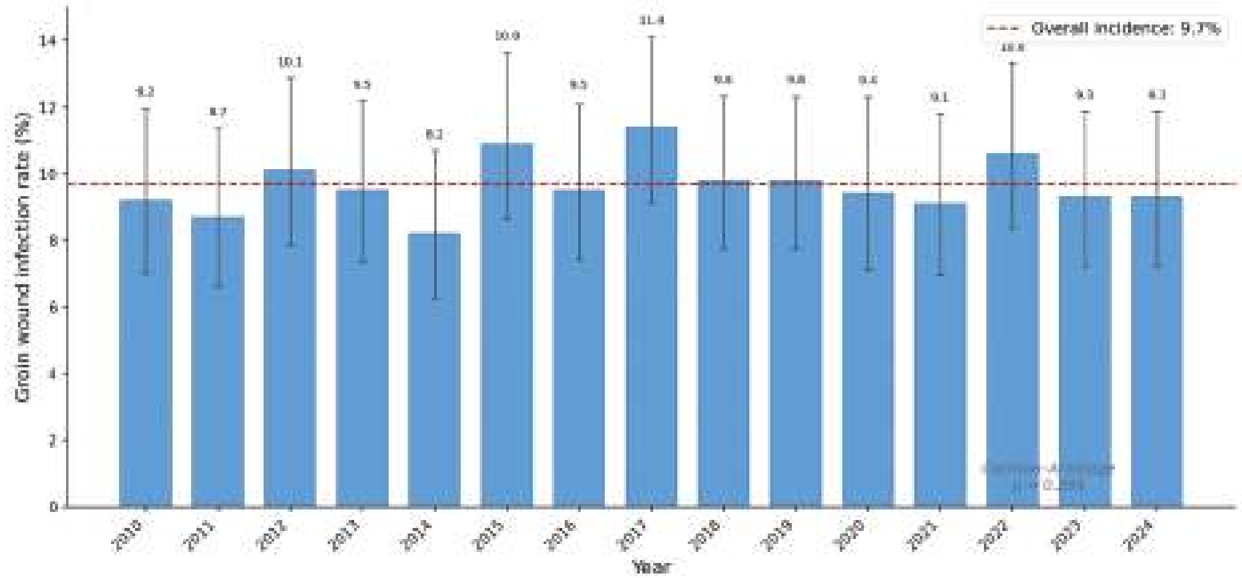
Culture results were available for 724 of 846 infection episodes (85.6%): 219 of 253 (86.6%) in 2010–2014, 276 of 322 (85.7%) in 2015–2019, and 229 of 271 (84.5%) in 2020–2024, indicating stable sampling practice across periods. Staphylococcus aureus was the single most common isolate, identified in 319 episodes (44.1% of culture-positive cases). Coagulase-negative staphylococci accounted for 98 (13.5%), Escherichia coli and other Enterobacterales for 131 (18.1%), Pseudomonas aeruginosa for 47 (6.5%), enterococci for 52 (7.2%), anaerobes for 29 (4%), and polymicrobial growth was recorded in 48 (6.6%) **(Table 4).**

The proportion of MRSA among all S. aureus isolates rose steadily across the three five-year periods: 19 of 88 (21.6%) in 2010–2014, 38 of 122 (31.1%) in 2015–

Table 3. Annual infection rates

Year	Incisions	SSI, n	Rate %	Superficial incisional	Deep	Organ/space (graft)
2010	524	48	9.2	28	13	7
2011	538	47	8.7	26	15	6
2012	556	56	10.1	32	16	8
2013	568	54	9.5	30	17	7
2014	584	48	8.2	29	14	5
2015	598	65	10.9	37	19	9
2016	612	58	9.5	35	16	7
2017	628	72	11.4	42	21	9
2018	642	63	9.8	37	17	9
2019	656	64	9.8	38	18	8
2020	488	46	9.4	26	14	6
2021	548	50	9.1	27	15	8
2022	592	63	10.6	37	18	8
2023	604	56	9.3	34	14	8
2024	604	56	9.3	32	18	6
Total	8,742	846	9.7	490	245	111

Cochran–Armitage trend test $p = 0.284$.



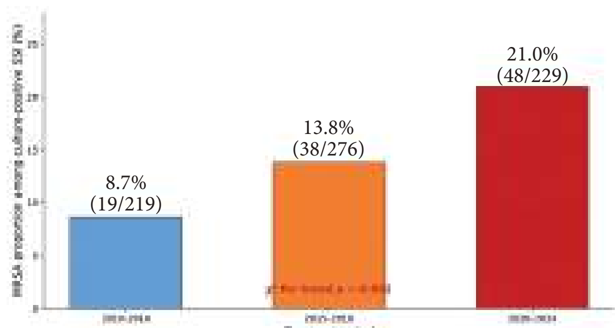
Graph 1. Annual groin wound infection rate (%), 2010–2024. Error bars: Wilson 95% confidence intervals. Dashed line: overall 15-year incidence (9.7%). Cochran–Armitage trend test p = 0.284.

Table 4. Microbiological spectrum by five-year period

Organism	2010–2014	2015–2019	2020–2024	
S. aureus (MSSA)	69 (31.5)	84 (30.4)	61 (26.6)	214 (29.6)
S. aureus (MRSA)	19 (8.7)	38 (13.8)	48 (21.0)	105 (14.5)
Coagulase-neg. staph.	32 (14.6)	37 (13.4)	29 (12.7)	98 (13.5)
Escherichia coli	30 (13.7)	36 (13.0)	28 (12.2)	94 (13.0)
Other Enterobacterales	12 (5.5)	14 (5.1)	11 (4.8)	37 (5.1)
Pseudomonas aeruginosa	15 (6.8)	18 (6.5)	14 (6.1)	47 (6.5)
Enterococcus spp.	17 (7.8)	20 (7.2)	15 (6.6)	52 (7.2)
Anaerobes	9 (4.1)	11 (4.0)	9 (3.9)	29 (4.0)
Polymicrobial	16 (7.3)	18 (6.5)	14 (6.1)	48 (6.6)
Culture-positive total	219	276	229	724*
Culture-negative	34	46	42	122

Denominators are culture-positive episodes per period (2010–2014: 219; 2015–2019: 276; 2020–2024: 229; total: 724). Values are n (% of culture-positive episodes in that period). MSSA = methicillin-susceptible S. aureus; MRSA = methicillin-resistant S. aureus. *724/846 = 85.6% culture positivity. χ^2 for MRSA trend across periods: p < 0.001.

2019, and 48 of 109 (44%) in 2020–2024 (χ^2 for trend p < 0.001). When expressed as a fraction of all culture-positive episodes regardless of organism, MRSA increased from 8.7% (2010–2014) to 13.8% (2015–2019) to 21% (2020–2024) across the same intervals **(Graph 2).** In a crude logistic regression model with five-year period coded as an ordinal variable (1, 2, 3) and culture-positive methicillin-resistant Staphylococcus aureus as the outcome, the odds ratio per period was 1.56 (95% confidence interval 1.28–1.91; denominator: all 724 culture-positive episodes). Gram-negative organisms remained relatively stable at approximately 23–26% of culture-positive episodes throughout the study period. No vancomycin-resistant enterococci were detected.



Graph 2. Methicillin-resistant Staphylococcus aureus as a proportion of all culture-positive groin wound infections across three five-year periods (2010–2014, 2015–2019, 2020–2024). χ^2 for trend p < 0.001.

Discussion

In this 15-year cohort of nearly nine thousand femoral-access groin incisions at a single vascular center in southeastern Europe, the two clinically most relevant findings were the stable overall wound infection incidence of 9.7% and the increasing methicillin-resistant Staphylococcus aureus proportion among culture-positive infections. Additionally, infection severity was not uniform across procedure types, with bypass operations accounting for a disproportionate share of deep and organ/space infections.

The overall rate of 9.7% aligns with the 8.6% reported by the multicenter Groin wound Infection after Vascular Exposure (GIVE) cohort from 37 centers in the United Kingdom [1], and falls within the 5–15% range cited in recent systematic reviews [3,5]. No decline in wound infection incidence was observed across the study period. Similar stable rates have been described in contemporary vascular surgery series, although direct comparison is limited by differences in surveillance definitions and case mix [6,12]. One possible explanation is that increasing patient complexity may have offset improvements in perioperative technique and infection-prevention practice, as rising prevalence of diabetes, obesity, and immunosuppressive therapy – offsets improvements in technique and infection-prevention bundles.

The unadjusted procedure-specific gradient observed here – highest after infrainguinal bypass (13%), intermediate after aortobifemoral reconstruction (12%), and lowest after endovascular groin cutdown (5.5%) – mirrors the pattern described by Jim and colleagues using the NSQIP database [13]. The higher rates after bypass procedures likely reflect a combination of operative complexity, prosthetic use, and underlying patient risk profile rather than an independent procedural effect. The relatively high organ/space proportion after bypass operations (12.5%) underscores the vulnerability of prosthetic conduits to late haematogenous and contiguous seeding.

Methicillin-resistant Staphylococcus aureus accounted for 8.7% of culture-positive infections in 2010–2014 and 21% in 2020–2024, indicating a marked increase over time. Between the first and last five-year periods, the MRSA share among staphylococcal isolates approximately doubled, from 22% to 44%. This trend echoes surveillance data from vascular units in Italy and Germany [7,8] and has practical consequences: standard cephalosporin-based prophylaxis may offer inadequate coverage for a growing subset of patients. Several guidelines suggest that MRSA-active prophylaxis may be considered when local MRSA prevalence among SSI pathogens is high, particularly in the context of prosthetic implantation [10,14]. At our institution, the observed MRSA proportions now fall within a range in which some guidelines consider augmented prophylactic coverage, although any policy change should be based on local stewardship review [15].

Gram-negative organisms, predominantly Escherichia coli and Pseudomonas aeruginosa, remained relatively stable at approximately 23–26% of culture-positive episodes throughout the study period. The stable gram-negative proportion should be interpreted alongside emerging reports of extended-spectrum β-lactamase producers in vascular wound infections at other centers [7], which warrants continued local antibiogram monitoring.

The study includes all eligible procedures performed at the institution during the 15-year period, which strengthens internal completeness of surveillance data and supports genuine trend analysis; however, referral-related case mix may still limit external generalizability. Blinded dual-surgeon adjudication and a standardized 90-day follow-up window reduce both ascertainment bias and under-reporting. The main limitations are as follows. First, the single-center design restricts generalizability; the observed MRSA trajectory should be interpreted primarily as an institutional surveillance signal and should not be extrapolated directly to centers with different case-mix, microbiological ecology, or prophylaxis protocols. Second, the retrospective nature precluded collection of certain variables such as nasal MRSA carriage status, details of skin preparation, and compliance with prophylaxis timing. Third, wound cultures were obtained at the treating surgeon's discretion rather than by standardized protocol; microbiological trend analyses were therefore restricted to culture-positive infections and may have been influenced by temporal variation in sampling practices, which could not be fully reconstructed retrospectively. Fourth, 1,282 procedures were excluded, including 203 with insufficient documentation; a comparison of included and excluded cases was not possible because the excluded group lacked the outcome data needed for meaningful comparison. Fifth, missing baseline data (such as body mass index in patients without recent measurement) were not systematically quantified; however, the core variables used in trend analysis were complete for all included cases. Sixth, because 8,742 incisions arose from 7,218 patients (21.1% contributing more than one incision), within-patient correlation was not modeled in the trend analysis; confidence intervals and p-values may therefore be modestly underestimated. A cluster-corrected model (e.g. generalized estimating equations with patient-level clustering) would be desirable but was beyond the scope of this descriptive report. Finally, culture-negative infections (14.4%)

may include both true infections with fastidious organisms and cases treated empirically before sampling, potentially underestimating the MRSA burden.

Conclusion

Over a 15-year period, approximately one in ten groin incisions for femoral vascular access developed a wound infection, with no measurable decline across the observation period. Bypass procedures had the highest unadjusted infection rates and the greatest proportion of deep and graft-level infections. The steady and substantial rise in methicillin-resistant Staphylococcus aureus prevalence –from approximately 9% to 21% of culture-positive episodes – supports institutional review of prophylaxis and antimicrobial stewardship policies, particularly where similar resistance patterns are confirmed in the local antibiogram. Prospective surveillance incorporating nasal screening and prophylaxis-outcome linkage would help determine whether targeted methicillin-resistant Staphylococcus aureus decolonisation or augmented antibiotic regimens can reduce this persistent complication.

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Rad je primljen 21. III 2026.
Recenziran 6. IV 2026.
Prihvaćen za štampu 6. IV 2026.
BIBLID.0025-8105:(2026):LXXIX:1-2:11-17.