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Microbiological and Therapeutic Insights into Primary Breast Abscesses: A Retrospective Study

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ABSTRACT

Backgrounds: Breast abscess is a common health issue among women, particularly those who are lactating or of childbearing age. Timely and effective antibiotic therapy along with appropriate surgical intervention is essential for treating bacterial infections associated with breast abscesses. This study aimed to investigate the clinical presentations, common pathogens, and treatment practices (including antibiotic therapy and surgical interventions) of primary breast abscesses in lactating and non-lactating women in a tertiary hospital.
Materials & Methods: This retrospective study was conducted on women diagnosed with primary breast abscesses in a tertiary hospital from January 1, 2019 to January 1, 2023. Patients were identified through the hospital microbiology laboratory database and electronic health records. Data were collected on patient demographics, comorbidities, smoking history, clinical presentations, treatment modalities, pus culture and antibiotic sensitivity reports, and clinical outcomes
Findings: The study comprised 85 patients. *Bacillus* species was the most frequently-identified pathogen (35.3%), followed by methicillin-sensitive *Staphylococcus aureus* (25.9%). Sensitivity reports indicated that these organisms were generally susceptible to co-amoxiclav, flucloxacillin, and ciprofloxacin. These antibiotics were the most commonly-prescribed and effective medications when used in conjunction with ultrasound-guided aspiration (88%), surgical incision and drainage (19%), or both.
Conclusion: *Bacillus* species emerged as the most common pathogen responsible for primary breast abscesses in this cohort. Although bacterial resistance was not prevalent, understanding the current bacteriological profile of breast abscesses is vital for selecting appropriate empirical antibiotic therapy and developing evidence-based treatment guidelines.

Keywords: Breast disease, Bacillus, Retrospective study, Antibiotics, Microbial sensitivity

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Introduction

A breast abscess is a localized collection of pus in breast tissue. It is a common condition, particularly affecting women who are lactating or of childbearing age. Breast infections are closely linked to lactation, with 10 to 33% of lactating women experiencing breast infections [1].

Breast abscesses could be classified based on their location (subareolar, central, or peripheral) or causes (lactational or non-lactational) [2]. Both lactating and non-lactating women with untreated mastitis are at increased risk of developing breast abscesses. Studies have reported that 4.6 to 11% of women with mastitis develop breast abscesses [1, 2].

Lactational abscesses commonly occur within a year after childbirth or during ongoing breastfeeding [3]. Risk factors include early postpartum period, first-time motherhood, maternal age over 30 years, prolonged pregnancies beyond 41 weeks, and a history of mastitis [4]. Non-lactational breast abscesses are less common but occur more frequently in African-American women, smokers, and individuals with diabetes or obesity [5, 6]. Less common risk factors include immunosuppression, skin conditions like hidradenitis suppurativa, nipple piercings, duct ectasia, trauma, breast cancer, and fat necrosis [7-9].

Patients typically present with breast lumps, localized warmth, pain, tenderness, swelling, and sometimes flu-like symptoms [6-8]. Most primary breast abscesses are caused by commensal Gram-positive bacteria, with Gram-negative and anaerobic organisms being less frequent [10, 11]. Treatment depends on identifying the causative organism and its antibiotic sensitivity [12, 13]. Anti-staphylococcal penicillins are often used as first-line empirical therapy [1, 2]. For larger abscesses, surgical incision and drainage (I&D) is standard [1]. However, in recent years, ultrasound-guided (USG) aspiration combined with antibiotic therapies has become a preferred, less invasive option [14-16]. Therefore, the efficacy of antimicrobial therapy plays a pivotal role in ensuring the success of this approach.

Antimicrobial resistance (AMR) is a growing concern, which complicates treatment decisions [10]. Resistant organisms, such as methicillin-resistant *Staphylococcus aureus* (MRSA) are becoming more common, and their prevalence varies by region [17]. This highlights the need for accurate local microbiological data to guide empirical treatment and reduce drug resistance and health care costs [17].

Objectives: This retrospective cohort study aimed to investigate the clinical presentations and common pathogens of primary breast abscesses in both lactating and non-lactating women in a tertiary hospital. The study also examined antibiotic prescribing patterns and the effectiveness of surgical interventions to provide evidence-based treatment recommendations.

Materials and Methods

This retrospective cohort study was conducted over a 4-year period from January 1, 2019 to January 1, 2023. The study included all female patients who presented with a diagnosis of primary breast abscess to the Emergency Department and Surgical Department of Raja Isteri Pengiran Anak Saleha (RIPAS) Hospital, a tertiary referral center in Brunei Darussalam.

Eligible participants were lactating and non-lactating women aged 18 years and older, who presented with clinical signs and symptoms consistent with primary breast abscess, including breast pain or tenderness, swelling, erythema, localized warmth, nipple discharge, fluctuance, or induration. Exclusion criteria included male patients with breast abscesses, patients with breast

abscesses due to non-bacterial etiologies (e.g., fungal or parasitic infections), patients with secondary breast infections resulting from surgical procedures (i.e., surgical site infections), and patients under the age of 18. Patients were identified through the RIPAS Hospital Microbiology Laboratory database by screening pus samples labeled as "breast abscess", sent from the emergency department and surgical department. Patient data were retrieved from the Brunei Darussalam Healthcare Information and Management System, the hospital's electronic medical records platform.

The collected data included demographic information including age, lactational status, and smoking history; clinical history including medical comorbidities (e.g., diabetes, obesity, duration of symptoms, and prior episodes of mastitis or abscess); treatment details including type and duration of empirical antibiotic therapy and performed interventions (e.g., USG aspiration and I&D); microbiological profile including culture and sensitivity results of abscess aspirates or surgical drainage specimens; and outcomes like symptom resolution, time to clinical improvement, abscess recurrence, complications, and follow-up duration. Patients with incomplete or missing records were excluded from the analysis.

Treatment effectiveness was assessed based on documented clinical improvement within 7 to 10 days after the initiation of treatment, defined as resolution of pain, erythema, swelling, and fever, as well as reduction in abscess size where applicable. For antibiotic therapy, effectiveness was evaluated by matching the prescribed empirical antibiotic with subsequent culture sensitivity results and assessing the need for antibiotic change. Surgical treatment effectiveness was assessed by the need for repeated interventions, the rate of abscess recurrence, and post-procedure complications [15, 16].

Potential confounding factors, including comorbidities such as diabetes mellitus, smoking status, and obesity, were recorded and analyzed. Subgroup analyses were performed to evaluate the association between these variables and treatment outcomes, including response to antibiotics, recurrence rate, and need for surgical intervention.

Microbiological analysis: Pus samples obtained from patients were submitted to the RIPAS Hospital Microbiology Laboratory for culture and sensitivity testing. For aerobic and facultative anaerobic bacteria, specimens were processed according to standard operating procedures. Samples were cultured on blood agar, MacConkey agar, and chocolate agar (Oxoid, Thermo Fisher Scientific, USA) and incubated under aerobic conditions at 35–37 °C for 48–24 hours. Bacterial isolates were identified based on colony morphology, Gram staining, and biochemical tests (API 20E, API Staph, and VITEK 2, bioMérieux, France). For anaerobic bacteria, selective anaerobic culture media e.g., anaerobic blood agar or Schaedler agar (Oxoid, Thermo Fisher Scientific, USA) were used. Samples intended for anaerobic culture were transported using anaerobic transport media and processed in an anaerobic chamber or jars with gas-generating systems to maintain an oxygen-free environment. Anaerobic plates were incubated at 35–37 °C for 72–48 hours. Identification of anaerobes was conducted using biochemical tests **(**API 20A bioMérieux, France). However, as per routine clinical practice, during the study period, anaerobic cultures were not consistently requested or performed for all patients, particularly when the pus sample volume was limited or when anaerobic infection was not clinically suspected.

Antibiotic susceptibility testing: Antimicrobial susceptibility testing was performed for all bacterial isolates using the VITEK 2

automated system (bioMérieux, France) in the Microbiology Laboratory of RIPAS Hospital in accordance with Clinical and Laboratory Standards Institute (CLSI) guidelines [18]. Methicillin resistance in Staphylococci was interpreted using oxacillin Minimum Inhibitory Concentration (MIC) breakpoints or susceptibility to cefoxitin, as specified by the CLSI [18].

Table 1) Sociodemographic and past medical history of 85 patients with primary breast abscess

Sociodemographic	Number of Patients (%)
Age (years)	
<20	2 (2)
20 – 29	22 (26)
30 – 39	32 (38)
40 – 49	15 (18)
50 – 59	8 (9)
60 – 69	4 (5)
70 – 79	0 (0)
80 – 89	2 (2)
Weight (in kg)	
N/A	19 (22)
40 – 49	9 (11)
50 – 59	13 (16)
60 – 69	23 (27)
70 – 79	11 (13)
80 – 89	8 (9)
90 – 99	2 (2)
Smoking status	
Smoking	1 (1)
No smoking	84 (99)
Lactation Status	
Lactating	33 (39)
Non-lactating	52 (61)
Previous medical history	
Diabetes	49 (58)
Obesity	57 (67)
Hypertension	52 (61)
Dyslipidemia	31 (36)
Previous breast lump / abscess	29 (34)

N/A: Not available

Statistical analysis: All statistical analyses were conducted using RStudio software. Descriptive statistics were presented as frequencies and percentages for categorical variables. For numerical variables, means and standard deviations were reported for normally distributed data, while medians and interquartile ranges were used for non-normally distributed data. Comparisons between categorical variables (e.g., recurrence rates by lactational status or comorbidities) were performed using Chi-square test or Fisher's exact test where appropriate. A *p*-value of less than .05 was considered statistically significant.

Findings

During the study period from January 1, 2019 to January 1, 2023, a total of 101 patients with primary breast abscess were

Table 2) Frequency of bacterial species responsible for causing breast abscesses in this study

Microorganism	Frequency (%)
Bacillus species	30 (35.3)
Methicillin-sensitive *Staphylococcus aureus*	22 (25.9)
Coagulase negative *Staphylococcus*	12 (14.1)
Methicillin-resistant *Staphylococcus aureus* (MRSA)	4 (4.7)
Pseudomonas aeruginosa	3 (3.5)
Streptococcus sanguinis	2 (2.3)
Acinetobacter baumannii	2 (2.3)
Diphtheroids bacilli	2 (2.3)
Escherichia coli	1 (1.2)
Burkholderia cepacia	1 (1.2)
Enterobacter cloacae complex	1 (1.2)
Staphylococcus capitis	1 (1.2)
Enterobacter gergoviae	1 (1.2)
Cronobacter sakazakii group	1 (1.2)
Paenibacillus polymyxa	1 (1.2)
Klebsiella pneumoniae ssp. *pneumoniae*	1 (1.2)

identified. Of whom, 85 cases met the eligibility criteria for inclusion in the study, while the remaining 16 cases were excluded due to incomplete data.

Patients' demographics: Sociodemographic data of all patients, including age, weight, smoking status, lactational status, and past medical history, are shown in Table 1. The mean age of the 85 eligible patients was 38 years (range: 18 – 85 years). Almost all patients (99%) were non-smokers, 67% were obese, 58% had a history of diabetes, and 34% had a past history of breast lumps or breast abscesses. There were more non-lactational abscesses than lactational abscesses (61% versus 39%). Forty (47%) patients presented with abscess in the right breast, 36 (42%) patients with abscess in the left breast, and nine (11%) patients with bilateral breast abscess. The common presentations of patients were erythema (n=41, 48%), induration (n=44, 52%), fluctuance (n=79, 93%), warmth (n=34, 40%), and tenderness to touch (n=58, 68%). Only 12 (14%) patients presented with a discharging abscess.

Table 3) Therapeutic approaches for primary breast abscesses (antibiotics, ultrasound-guided aspiration, incision and drainage) stratified by Gram-positive and Gram-negative microorganisms in this study

Antibiotics	Microorganism				
	N	Overall N = 85 [a] N (%)	Gram-Positive N = 74 [a] N (%)	Gram-Negative N = 11 [a] N (%)	*P*-Value
Empirical Abx	68				.545 [b]
Co-amoxiclav		48 (71)	39 (68)	9 (82)	
Flucloxacillin		4 (5.9)	4 (7.0)	0 (0)	
Cefuroxime		4 (5.9)	2 (2.7)	2 (18)	
Cefalexin		2 (2.9)	2 (3.5)	0 (0)	
Ciprofloxacin		3 (4.4)	3 (5.3)	0 (0)	
Fusidic Acid		3 (4.4)	3 (5.3)	0 (0)	
Cloxacillin		3 (4.4)	3 (5.3)	0 (0)	
Ceftriaxone		1 (1.5)	1 (1.8)	0 (0)	
Change in Abx	40				.454 [b]
Co-amoxiclav		17 (42)	13 (41)	4 (50)	
Flucloxacillin		11 (28)	8 (25)	3 (38)	
Cefuroxime		1 (2.5)	1 (3.1)	0 (0)	
Ciprofloxacin		8 (20)	8 (25)	0 (0)	
Co-trimoxazole		1 (2.5)	1 (3.1)	0 (0)	
Cloxacillin		2 (5.0)	1 (3.1)	1 (12)	
USS aspiration	85				.611 [b]
Yes		75 (88)	66 (89)	9 (82)	
No		10 (12)	8 (11)	2 (18)	
Incision and Drainage	85				.029 [b]
Yes		16 (19)	11 (15)	5 (45)	
No		69 (81)	63 (85)	6 (55)	

N: Number of patients receiving the treatment, Abx: antibiotic, USS: ultrasound scan
[a]: frequency (%), [b]: Fisher's exact test

Microorganisms in pus culture: In our series of primary breast abscess, all patients had monomicrobial infections. The most common pathogenic species responsible for causing primary breast abscesses in the studied patients was *Bacillus* species (35.3%), followed by methicillin-sensitive *S. aureus* (MSSA) (25.9%), coagulase-negative Staphylococci (14.1%), and MRSA (4.7%) (Table 2). Co-amoxiclav was the most common antibiotic prescribed as empirical treatment (71%), followed by flucloxacillin (5.9%), cefuroxime (5.9%), ciprofloxacin, fusidic acid, and cloxacillin (each 4.4%) (Table 3). Empirical antibiotics prescribed for Gram-positive bacteria causing primary breast abscesses appeared to be more diverse compared to Gram-negative bacteria, which were mainly prescribed with either co-amoxiclav (82%) or cefuroxime (18%). A similar finding was observed regarding changes in treatment after access to antibiotic sensitivity reports, as most empirical treatments were adjusted to co-amoxiclav (42%), flucloxacillin (28%), or ciprofloxacin (20%). Most patients with primary breast abscess underwent USG aspiration (88%), with or without the addition of antibiotics. Of all patients, only 19% underwent surgical I&D.

Table 3 shows the treatment (empirical antibiotics, change in antibiotics, USG aspiration and I&D) stratified by Gram-positive and Gram-negative microorganisms in this study. The type of microorganisms, classified by Gram staining (i.e., Gram-positive or Gram-negative), was not significantly associated with the choice of empirical antibiotic therapy, the modification of antibiotics after observing sensitivity results, or the decision to perform USG aspiration**.** However, the findings showed that 45% of patients with Gram-negative bacteria required I&D, while only 15% of patients with Gram-positive bacteria required I&D (p = .029), indicating that patients infected with Gram-negative organisms were significantly more likely to require I&D compared to those infected with Gram-positive organisms (Table 3).

The sensitivity reports of all 85 Gram-positive (n=74) and Gram-negative (n=11) bacteria are shown in Table 4. Susceptibility testing was only interpreted for isolates with established CLSI interpretive criteria [18]. Isolates were not tested for susceptibility to some antimicrobial agents. The laboratory deemed this test to be unnecessary based on typical resistance patterns and hospital guidelines. According to the results, a total of 18 (21%) bacteria were sensitive to amikacin, of which 10 (91%, 10 of 11) were Gram-negative, 8 (11%, 8 of 74) were Gram-positive bacteria. Also, 5 (5.9%) microorganisms were sensitive to co-amoxiclav, of which 2 (2.7%) were Gram-positive bacteria, and 3 (27%) were Gram-negative bacteria. Ampicillin, levofloxacin, meropenem, and netilmicin were found to be effective against both Gram-positive and Gram-negative bacteria. No resistance to these 4 antibiotics was observed in Gram-positive bacteria, resistance was observed only in Gram-negative bacteria.

Gram-negative bacteria were found to be either sensitive (45%) or intermediately sensitive (9.1%) to ampicillin/sulbactam. The same findings were observed for cefepime among these bacteria (18% sensitive and 9.1% intermediately sensitive). Gram-negative bacteria were found to be equally sensitive and resistant to cefoperazone, while these bacteria were much more sensitive (91%) than resistant (9.1%) to ceftazidime. Also, 36% of Gram-negative bacteria were sensitive to ceftriaxone, 18% were intermediately sensitive, and 9.1% were resistant. Gram-negative bacteria were sensitive to ertapenem (45%) but resistant to cefuroxime (oral and parenteral). Gram-positive bacteria were mostly sensitive (48%) to clindamycin, while only 7.1% were intermediately

sensitive, and 9.4% were resistant to this antibiotic, the same findings were observed for susceptibility to erythromycin among these bacteria. Gram-positive bacteria were almost equally sensitive and resistant to fusidic acid and oxacillin. The same findings were

Table 4) Antibiotic sensitivity of Gram-positive and Gram-negative bacteria isolated from 85 patients in this study

Antibiotics	Microorganism		
	Overall N = 85 [a] N (%)	**Gram-Positive N = 74 [a] N (%)**	**Gram-Negative N = 11 [a] N (%)**
Amikacin			
Sensitive	18 (21)	8 (11)	10 (91)
Intermediate	1 (1.2)	1 (1.4)	0 (0)
Resistant	1 (1.2)	0 (0)	1 (9.1)
Susceptible dose dependent	4 (4.7)	4 (5.4)	0 (0)
Co-amoxiclav			
Sensitive	5 (5.9)	2 (2.7)	3 (27)
Ampicillin			
Sensitive	4 (4.7)	2 (2.7)	2 (18)
Resistant	3 (3.5)	0 (0)	3 (27)
Ampicillin / Sulbactam			
Sensitive	5 (5.9)	0 (0%)	5 (45)
Intermediate	1 (1.2)	0 (0)	1 (9.1)
Resistant	1 (1.2)	0 (0)	1 (9.1)
Azithromycin			
Sensitive	2 (2.4)	2 (2.7)	0 (0)
Cefepime			
Sensitive	2 (2.4)	0 (0)	2 (18)
Intermediate	1 (1.2)	0 (0)	1 (9.1)
Resistant	1 (1.2)	0 (0)	1 (9.1)
Cefoperazone			
Sensitive	1 (1.2)	0 (0)	1 (9.1)
Resistant	1 (1.2)	0 (0)	1 (9.1)
Cefoxitin			
Sensitive	34 (40)	30 (41)	4 (36)
Resistant	8 (9.4)	8 (11)	0 (0)
Ceftazidime			
Sensitive	10 (12)	0 (0)	10 (91)
Resistant	1 (1.2)	0 (0)	1 (9.1)
Ceftriaxone			
Sensitive	7 (8.2)	3 (4.1)	4 (36)
Intermediate	2 (2.4)	0 (0)	2 (18)
Resistant	1 (1.2)	0 (0)	1 (9.1)
Cefuroxime oral			
Resistant	2 (2.4)	0 (0)	2 (18)

Antibiotics	Microorganism		
	Overall N = 85 [a] N (%)	Gram-Positive N = 74 [a] N (%)	Gram-Negative N = 11 [a] N (%)
Cefuroxime parenteral			
Resistant	2 (2.4%)	0 (0)	2 (18)
Chloramphenicol			
Sensitive	5 (5.9)	5 (6.8)	0 (0)
Intermediate	1 (1.2)	1 (1.4)	0 (0)
Ciprofloxacin			
Sensitive	59 (69)	51 (69)	8 (73)
Intermediate	3 (3.5)	2 (2.7)	1 (9.1)
Resistant	2 (2.4)	1 (1.4)	1 (9.1)
Clindamycin			
Sensitive	41 (48)	41 (55)	0 (0)
Intermediate	6 (7.1)	6 (8.1)	0 (0)
Resistant	8 (9.4)	8 (11)	0 (0)
Co-trimoxazole			
Sensitive	51 (60)	47 (64)	4 (36)
Resistant	2 (2.4)	2 (2.7)	0 (0)
Ertapenem			
Sensitive	5 (5.9)	0 (0)	5 (45)
Erythromycin			
Sensitive	49 (58)	49 (66)	0 (0)
Intermediate	2 (2.4)	2 (2.7)	0 (0)
Resistant	4 (4.7)	4 (5.4)	0 (0)
Fusidic Acid			
Sensitive	29 (34)	29 (39)	0 (0)
Resistant	23 (27)	23 (31)	0 (0)
Gentamicin			
Sensitive	61 (72)	52 (70)	9 (82)
Intermediate	2 (2.4)	1 (1.4)	1 (9.1)
Resistant	2 (2.4)	2 (2.7)	0 (0)
Imipenem			
Sensitive	7 (8.2)	0 (0)	7 (64)
Resistant	1 (1.2)	0 (0)	1 (9.1)
Levofloxacin			
Sensitive	9 (11)	5 (6.8)	4 (36)
Intermediate	1 (1.2)	0 (0)	1 (9.1)
Resistant	1 (1.2)	0 (0)	1 (9.1)
Linezolid			
Sensitive	13 (15)	13 (18)	0 (0)

Antibiotics	Microorganism		
	Overall N = 85 [a] N (%)	**Gram-Positive N = 74 [a] N (%)**	**Gram-Negative N = 11 [a] N (%)**
Meropenem			
Sensitive	11 (13)	1 (1.4)	10 (91)
Resistant	1 (1.2)	0 (0)	1 (9.1)
Netilmicin			
Sensitive	13 (15)	5 (6.8)	8 (73)
Resistant	1 (1.2)	0 (0)	1 (9.1)
Oxacillin			
Sensitive	27 (32)	27 (36)	0 (0)
Resistant	9 (11)	9 (12)	0 (0)
Penicillin			
Sensitive	5 (5.9)	5 (6.8)	0 (0)
Resistant	7 (8.2)	7 (9.5)	0 (0)
Susceptible Dose Dependent	2 (2.4)	2 (2.7)	0 (0)
Piperacillin			
Sensitive	9 (11)	0 (0)	9 (82)
Resistant	1 (1.2)	0 (0)	1 (9.1)
Piperacillin/Tazobactam			
Sensitive	8 (9.4)	0 (0)	8 (73)
Rifampicin			
Sensitive	2 (2.4)	2 (2.7)	0 (0)
Tetracycline			
Sensitive	41 (48)	41 (55)	0 (0)
Intermediate	2 (2.4)	2 (2.7)	0 (0)
Vancomycin			
Sensitive	29 (34)	29 (39)	0 (0)

[a] : frequency (%)

observed for imipenem and piperacillin among Gram-negative bacteria. Gram-negative bacteria were sensitive to piperacillin/tazobactam, while Gram-positive bacteria were sensitive and intermediately sensitive to tetracycline and vancomycin.

Recurrence: In this study, 29 (34%) patients experienced a recurrence of their breast abscess. Although not statistically significant, recurrence was more common in patients with Gram-positive bacteria (n=24, 83%) [95% CI: 64% to 93%] compared to patients with Gram-negative bacteria (n=5, 17%) [95% CI 6.5% to 36%] (p = .5).

Follow-up and complications: The mean follow-up period of the studied patients was 240 days (range: 18 – 1,109 days). The majority of patients (87%) who underwent USG aspiration, I&D, or both experienced no complications. Only 13% of patients experienced complications, with seroma being the most common complication observed (33%), followed by post-drainage infection (17%) and excessive wound bleeding (17%). For patients who underwent I&D, post-drainage infection was the most common complication (17%).

Discussion

This retrospective study included a total of 85 patients diagnosed with primary breast abscess over a 4-year period. It provides insight into the clinical characteristics, microbiological profiles, and treatment approaches of primary breast abscesses in women treated at a tertiary hospital in Brunei Darussalam. The key findings included the high prevalence of obesity and diabetes among patients, the unexpected predominance of *Bacillus* species in culture results, the preference for broad-spectrum antibiotics in empirical treatment, and the widespread use of USG aspiration as a first-line intervention.

The findings support existing literature indicating that women of childbearing age and lactating women are at increased risk of developing breast abscesses [1, 4-6]. In this study, the most affected age groups were 20–29 (26%) and 30–39 (38%) years, reflecting the reproductive age range. A significant proportion of patients were obese (67%) and lactating (39%) and had comorbidities such as diabetes mellitus (58%), hypertension (61%), and dyslipidemia (36%). Interestingly, 34% had a prior history of breast abscesses or breast lumps. Although smoking is a known risk factor, nearly all patients in our cohort were non-smokers. This finding may reflect cultural norms in Brunei Darussalam, where smoking is less prevalent among women. The most common presenting symptom was fluctuance (93%), followed by tenderness (68%), induration (52%), erythema (48%), and warmth (40%). These findings are consistent with scientific literature, though the high rate of fluctuance may suggest delays in seeking medical attention, allowing for more advanced abscess formation [6-8]. Erythema and warmth, suggestive of inflammation, were also present, particularly in lactating women, likely related to underlying or concurrent mastitis [4, 19].

Contrary to the present study findings, global reports identify *S. aureus*, including MRSA, as the most common causative agent of breast abscesses, followed by coagulase-negative Staphylococci, Diphtheroid, *Pseudomonas aeruginosa, Proteus mirabilis*, and other isolates [20, 21]. A combination of *S. aureus*, streptococcal, and anaerobic bacteria frequently results in non-lactational breast abscesses [1]. In this study, *Bacillus* species was found to be the most prevalent pathogen, followed by MSSA and coagulase-negative Staphylococci.

Bacillus species, traditionally considered non-pathogenic environmental organisms or laboratory contaminants, have in recent years been increasingly recognized as true pathogens in a variety of clinical settings. They have been found to be implicated in serious infections such as bacteremia, endophthalmitis, wound infections, abscesses, and even life-threatening septicemia, particularly among immunocompromised individuals as well as healthy patients [22]. This shift is thought to be due to a combination of factors, including better diagnostic technologies, increased clinical awareness, and possibly changing environmental conditions that favor *Bacillus* proliferation and pathogenicity.

In the context of Brunei Darussalam, the high prevalence of *Bacillus* species in breast abscesses may be influenced by the country's warm and humid climate, as the average temperature (25 to 35 °C) provides optimal conditions for the growth and survival of these bacteria [23, 24]. These findings suggest that *Bacillus* species, although often dismissed as contaminants, should be considered as potential pathogens in tropical and subtropical healthcare settings, particularly when clinical signs of infection are evident. These findings also highlight the importance of understanding regional

microbial ecology when planning treatment strategies.

Standard recommendations suggest the use of flucloxacillin for the treatment of MSSA infections, provided that MRSA is not a common local pathogen [19]. This aligns with the national hospital antibiotic guidelines adopted at RIPAS Hospital [25]. However, this study found that co-amoxiclav was the most commonly-prescribed empirical antibiotic, likely due to its broader spectrum of activity, followed by flucloxacillin, ciprofloxacin, cefuroxime, fusidic acid, and cloxacillin.

This prescribing trend may reflect clinical preferences for broader coverage in the absence of immediate microbiological confirmation [26]. While flucloxacillin remains an effective narrow-spectrum agent for Gram-positive organisms, it excludes MRSA and may be underused for this reason [27]. Nearly half (47%) of patients required changes to their initial antibiotic regimen, most commonly switching to co-amoxiclav, flucloxacillin, or ciprofloxacin. These changes were consistent with culture sensitivity results, indicating a responsive prescribing pattern guided by microbial data.

Minimally invasive approaches are increasingly favored in breast abscess management [19]. This policy is adopted at RIPAS hospital, observed in 88% of patients undergoing USG aspiration and only 19% of patient requiring I&D. Surgical intervention remains essential in cases where aspiration is unsuccessful or pus accumulation is too thick. Our study observed that 45% of patients with Gram-negative bacterial breast abscesses required I&D, compared to only 15% of those with Gram-positive infections ($p = .029$). This significant difference suggests that Gram-negative infections may present with more severe or complicated abscesses, necessitating surgical intervention. Some Gram-negative microorganisms exhibit higher resistance to standard antibiotics, potentially leading to treatment failure with conservative measures and necessitating surgical intervention. Patients with Gram-negative infections may present later in the disease course, with larger or more complex abscesses that require surgical drainage [28]. AMR is a growing global concern [29]. Physician prescribing behaviors are influenced by various factors, including clinical guidelines, local resistance patterns, and patient characteristics [30]. In this study, AMR in breast abscess pathogens was found to be relatively low. Most antibiotics prescribed were effective when taken at the correct dosage and duration, consistent with previous national findings [31]. However, AMR remains a looming threat. In 2019, Brunei Darussalam ranked 89th globally in terms of age-standardized mortality associated with AMR [32]. Continued surveillance, stewardship programs, and prescriber education are crucial to maintaining low resistance rates.

Despite appropriate treatment, recurrence remains a challenge. Contributing factors include delayed diagnosis, inadequate treatment, or unresolved patient risk factors such as diabetes, obesity, or smoking [19]. The observed recurrence in our cohort may be partially explained by the high prevalence of these comorbidities, which impair healing and increase susceptibility to reinfection.

While no formal sample size estimation was performed prior to data collection, the sample was sufficient to conduct descriptive and comparative analyses of microbiological profiles, antibiotic sensitivity patterns, and treatment outcomes. Nonetheless, it is acknowledged that the modest sample size may limit the detection of smaller effect sizes and restrict subgroup analyses, particularly for less common pathogens or rare comorbidities.

This study has several limitations. Firstly, of the 101 primary breast abscess cases

identified during the study period, 85 cases met the inclusion criteria and were included in the final analysis. The remaining 16 (15.8%) cases were excluded due to incomplete or missing data. Although necessary for maintaining data integrity, this exclusion may introduce selection bias, as excluded cases may systematically differ from included cases in terms of factors influencing outcomes, such as severity of infection, presence of comorbidities, or treatment received. Secondly, the small sample size of 85 patients may not accurately represent the entire population, given that the data were limited to patients from a single center. To achieve more reliable and validated results, future studies could adopt a multicenter approach. Thirdly, the pus samples analyzed were specifically labeled as 'breast abscess' in the microbiology lab. This excluded other potential breast abscess samples that might have been labeled with different terms by the physician. Lastly, this study was limited by its retrospective nature, where clinical data were extracted from the laboratory database and patient health records and therefore depended on the accuracy of recording at the time of clinical presentation.

Conclusion

This retrospective study describes the clinical features, microbial profile, and treatment outcomes of primary breast abscesses. Patients typically presented with fluctuance, tenderness, induration, erythema, and warmth. *Bacillus* species were the most frequently isolated pathogens, followed by MSSA and coagulase-negative Staphylococci, which were generally susceptible to co-amoxiclav, flucloxacillin, and ciprofloxacin. Although flucloxacillin is recommended as first-line therapy, co-amoxiclav was most commonly prescribed, likely due to its broader coverage. The findings support an evidence-based approach of early empirical antibiotic therapy (co-amoxiclav or flucloxacillin) combined with minimally invasive drainage as first-line treatment, reserving I&D for large or complex abscesses. Clinicians should be aware of unusual pathogens like *Bacillus* species and consider patient-specific risk factors (diabetes, obesity, lactation) to minimize recurrence. These insights can guide local protocols to optimize outcomes in breast abscess management.

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Ethical permissions: Ethical approval was obtained from the Institute of Health Science Research Ethics Committee (UBD/PAPRSBIHSREC/2022/120, dated December 22, 2022). Since this study was retrospective and did not require patient enrollment, consent forms were not also required. Patients were anonymized; identifiable data that could reveal the patient's identity were omitted.

Author's contributions: CCWH drafted the research proposal, collected the data, performed data analysis and interpretation, and drafted the manuscript. KKYY conceived the project, reviewed the proposal, critically reviewed the data analysis, and revised the manuscript. TRC collected and reviewed the data. ST collected and reviewed the data. All authors read and approved the final manuscript.

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