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ORIGINAL ARTICLE

Impact of Bilateral and Unilateral Post-Activation Potentiation on Immediate Cycling Performance

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ABSTRACT

Post Activation Potentiation (PAP) warm-up strategies are gaining attention for their potential to enhance athletic performance. This study aims to compare the effects of unilateral PAP (UPAP) and bilateral PAP (BPAP) on cycling performance. Using a randomised crossover experimental design, 50 trained recreational male cyclists, aged 18 to 40, participated. Each cyclist's regimen included 4 sets of 5 Repetition Maximum (RM) for back squats (BPAP) and rear leg elevated split squats (UPAP). The exercises were performed on separate occasions, followed by a Power Profile Test developed by the World Cycling Centre (WCC-PTT). Results showed that 85% of 1RM BPAP significantly improved 30-second average power, relative average power, average cadence, and average torque. Conversely, 42.5% 1RM UPAP notably enhanced peak power, peak cadence, and peak torque, with significant improvements in 6-second average power, relative average power, average cadence, and average torque. When the intensity of UPAP was reduced to 42.5%, significant improvements in average power output and average cadence were observed in the 4-minute test. This study highlights the importance of tailoring PAP type and intensity to the specific demands of the sport or event to enhance performance by effectively targeting relevant muscle groups.

Keywords: *Post Activation Potentiation, Bilateral, Unilateral, Cycling, Power Output*

INTRODUCTION

Warm-up is crucial for any physical activity of any level (Bishop, D., 2003). In Bishop's 2003 review, the author explores the physiological mechanisms behind warm-up routines and the effects of passive warm-up (heat application without physical activity) on exercise performance. Warm-up activity helps to increase body and muscle temperature, increase readiness to tackle heavy-duty activity, decrease stiffness, increase nerve-conduction rate, anaerobic energy provision and thermoregulatory strain, and reduce risk of injury (Bishop, D., 2003; Racinais et al., 2017). Blagrove et al. (2019) described that warm-up strategy in endurance athletes typically aims to achieve acute metabolic and cardiovascular adjustment which enhances the oxygen uptake, kinetic response, elevation of baseline oxygen consumption and acidaemia, which indirectly produces acute muscle preparedness. A study by Tomaras & MacIntosh (2011) on warm-up techniques indicates that athletes have been using the traditional warming-up method involving a general warm-up followed by a series of brief sprints lasting more than 50 minutes in total. This type of warm-up takes a longer time and gives lesser muscle readiness.

A major concern among coaches and athletes is that post-activation potentiation (PAP) can cause muscle fatigue which affects overall performance. Allen et al., 2008 mentioned that fatigue occurs when the muscle is incapable of generating an expected level of force during a contractile period. Reality-wise, PAP has proven to improve muscle readiness in a short period without causing muscle fatigue or injury to athletes (Chok & Daud., 2024; Wan, J. J. et al., 2017). Appleby et al. (2020) explained that heavy strength exercise improves the lower body strength of an athlete, and the study showed that there are not many significant differences between the usage of unilateral or bilateral strength workouts.

Del Rosso et al. (2016) investigated whether post-activation potentiation (PAP) could influence pacing strategies during a self-paced 30 km trial among half-marathon runners and reported that PAP could give acute muscle preparedness in performance improvement. PAP is the outcome of a voluntary contractile activity in which there is a significant enhancement of muscular twitch force (Mettler & Griffin, 2012). Hodgson et al. (2005) mentioned that the response of muscle groups to electrically induced stimuli is affected by the contractile history. PAP has been widely used in sprint, power and other events or training which require short and explosive movement. For sprinters and jumpers, there is enough evidence that showed improvement in performances after the completion of 5-12 minutes of heavy resistance exercise with more than 85% of 1 Repetition Maximum (Chiu et al., 2003; Maloney et al., 2014; Robin & Thomas, 2017).

However, heavy-strength PAP has not been explored thoroughly enough in the research world. Based on a meta-analysis study by Boullosa et al. (2018), there are only 22 studies done on the effect of PAP on endurance athletes involving distance runners, triathletes, duathletes, rowers, cyclists and cross-country skiers. Out of these studies, only one study done by Silva et al. (2014) focused on heavy-strength PAP for cyclists. Silva et al. (2014) implemented leg press (bilateral movement) as PAP before the 20km Time Trial (TT) for a 4-year experienced cyclist. His study showed the PAP group subjects improved in cycling economy and the time to complete the 20km TT reduced by 6.1%. There are no changes in power output and pedal cadence among the athletes.

On another note, cycling is a unilateral movement exercise (Douglas et al., 2021) that is performed in a unilateral non-weight-bearing phase (Olmedillas et al., 2012). In the form of strength exercise, single leg split squat,

which is a unilateral movement, focuses on the primary muscle quadriceps, gluteus muscles, hamstrings, adductors, abductors, and gastrocnemius as well, similar to the leg press (DeForest et al., 2014) but perform unilaterally. Therefore, this study aims to compare the effect of bilateral PAP (BPAP) and unilateral PAP (UPAP) on cyclists' performances. It was hypothesized that 4 sets of 5RM heavy strength exercises would increase the power output and improve the cycling performance of cyclists.

MATERIALS AND METHODS

This is a randomised crossover experimental study design, and this study is approved by the UMS Medical Research Ethics Committee [Code: JKEtika 3/21 (15)].

Subjects

Fifty (n=50) recreationally trained cyclists, with at least two years of recreational racing experience were chosen as subjects. Male cyclists aged 18-40 were selected as they were at the peak of their physiological development, in terms of muscle strength, reaction time, sensory abilities and cardiac functioning. Boundless Psychology (2019) mentioned that most professional athletes gave their best performances during this period. Subjects were those without any history of neurological or orthopaedic dysfunction, surgery or tenderness of the spine and lower extremities. Each subject was provided with a written informed consent form containing the risk factors and their rights to withdraw from the research at any time without reason, as per the University Research Ethics Committee.

Procedure

All subjects were seen five times during the period of study. On day one, subjects who volunteered for this study were first explained regarding the procedure and only those who could commit to the research timeframe (within 11 days) were enrolled into the program. As recommended by Yang et al. (2018), subjects were given 72 72-hour rest periods in between each testing session, 1 Repetition Maximum (RM) testing and World Cycling Centre – Power Profile Test (WCC-PPT) with PAP (Figure 1). Subjects were not allowed to perform any strenuous activities within 24 hours before each testing session. It was made compulsory for all subjects to perform 10 minutes of standardized general warm-up and active stretching before the test.

Figure 1: Subject performing the WCC-PPT with VO2 Max measurement taken during the testing.

On day two, all subjects had their anthropometry measurements (mass, height, body mass index and fat percentage) taken. Fat percentage was measured using the Tanita (UM-050) electronic weighing scale, which has a high accuracy and reliability of r = .934 (Vasold et. al, 2019). Each subject then performed the familiarisation session with the equipment set for the testing.

After 72 hours of rest, on day five, subjects had their 1RM testing for both unilateral (single-leg split squat) (Figure 2) and bilateral (back squat) (Figure 3). Subsequently, they were randomly grouped into Group A

and Group B (n = 25 in each group). On day nine of testing, Group A, first performed UPAP followed by WCC-PPT, whereas Group B performed BPAP followed by WCC-PPT. These groups were then swapped after 72 hours rest, on day eleven of testing, with Group A performing BPAP followed by WCC-PPT and Group B performing UPAP followed by WCC-PPT.

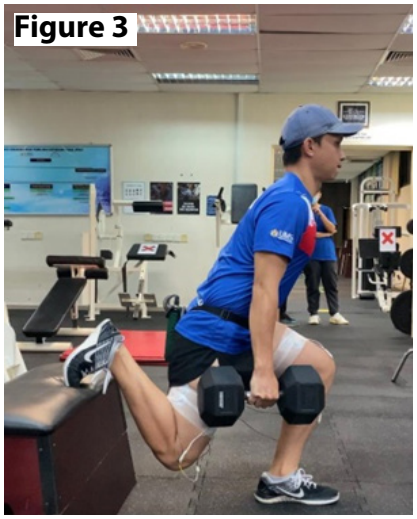

Figure 2, 3 : The Subject is in the starting phase of single leg split squat with 85% of 1RM load. The support box for this movement is measured at the height of the mid-patella of the subject (Figure 2). The subject is performing the single-leg split squat with 85% of 1RM load (Figure 3).

Figure 4, 5 : The subject was in the starting position before performing BPAP with 85% of 1RM load (Figure 4). The subject performed the BPAP with 85% of 1RM load (Figure 5).

Familiarization session

During the explanatory session, all subjects were introduced to the bicycle ergometer and explained the WCC-PPT protocol. All subjects were allowed to test the bicycle and run the protocol. The bicycle was fitted with the subject's pedal system and adjusted to each subject's preferred riding position. Subjects were allowed to bring their bicycle to compare the measurements to the bicycle ergometer. It was made compulsory for subjects to bring their own cycling attire, cycling shoes and cycling preferred pedal.

One Repetition Maximum (1RM)

Before the subject's test session on the bicycle ergometer, subjects obtained their 1RM weight for back squat using free weight barbell and single leg split squat using free weight dumbbell through an indirect method (Niewiadomski et al., 2008). The indirect method was used as the subjects were not from a strength training background and lighter weight was used to prioritize the safety of the subjects. Subjects were given enough rest in between the tests. Wathan's equation will be used to determine the subject's predicted 1RM because the calculated 1RM value using this equation did not differ significantly on average from the achieved 1RM performance (LeSuer et al. (1997).

$$1RM = (100 \times W) / (48.8 + (53.8 \times e\text{-}0.075 \times R))$$

Bilateral and Unilateral strength test

Subjects were needed to do 4 sets of 5RM of either bilateral or unilateral exercise (according to the assigned group in Chart 1) at 85% of the 1RM obtained previously during the 1RM testing session. 85% of the 1RM was selected as the weight for PAP. van den Tillaar & Saeterbakken (2019) stated that a four to five RM in back squats are used as it is the typical load used to improve maximal strength. Subjects were given 3-5 minutes of rest in between each set (Allen et al., 2008; Rønnestad et al., 2010).

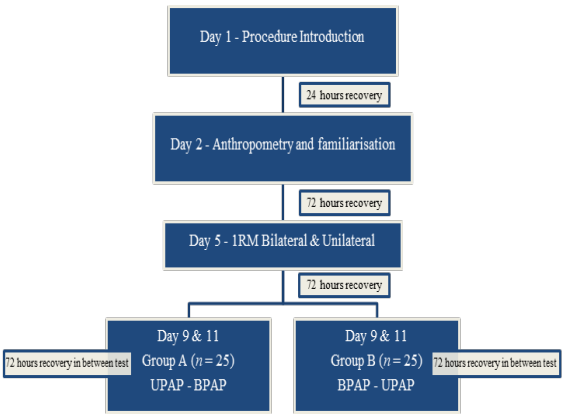

Chart 1: Framework of the study design including recovery time gap in between testing.

DeRenne (2010) recommended that post-PAP recovery time should be between 8-12 minutes. Based on a pilot study that was done using surface electromyography (SEMG) before this research, the results showed that the recovery time for BPAP was 12 minutes and 10 minutes for UPAP. Therefore, for this study, a recovery time of 12 minutes was used for BPAP and 10. minutes for UPAP before the WCC-PPT test.

World Cycling Centre - Power Profile Test (WCC-PPT). The WCC-PPT was developed by the World Cycling Centre (WCC), to provide coaches around the world with relevant information about cyclist potential (Gonzalez-Tablas et al., 2016; Gonzalez-Tablas & Martin-Santana., 2017). WCC-PPT assessed the cyclist's maximum capacity to produce power over duration that was strongly related to the physiological capacity required to perform a specific cycling race (Novak & Dascombe., 2014; Quod et al., 2010). WCC-PPT was conducted using the Lode Excalibur Sport (Lode BV Medical Technology Netherland). The reliability of r = 0.86 to 0.93 on a Lode cycle ergometer was proven by Driller, 2012; Dicks et al., 2016 and Earnest et al., 2005. The WCC-PPT protocol consists of four maximal efforts (6s, 6s, 30s, 4min), with active recovery in between. The 6-second and 30-second timeframe was an all-out effort sprint, whereas, for the 4-minute timeframe, subjects were required to pace their effort (Chart 2). During the active recovery period, subjects were instructed to continue pedalling at a light and comfortable intensity.

Analysis of results for each subject was based on the power, cadence and torque produced during each effort. Raw data produced from each effort were downloaded from the Lode Ergometry Manager (LEM) 10.11.0 software. LEM 10 (Partnumber: 955920) database was exported to Microsoft Excel to extract the raw results (Figure 6). The raw data of power, cadence and torque were then analysed using the SPSS system (IBM

Corp. (2022). IBM SPSS Statistics, Version 29.0).

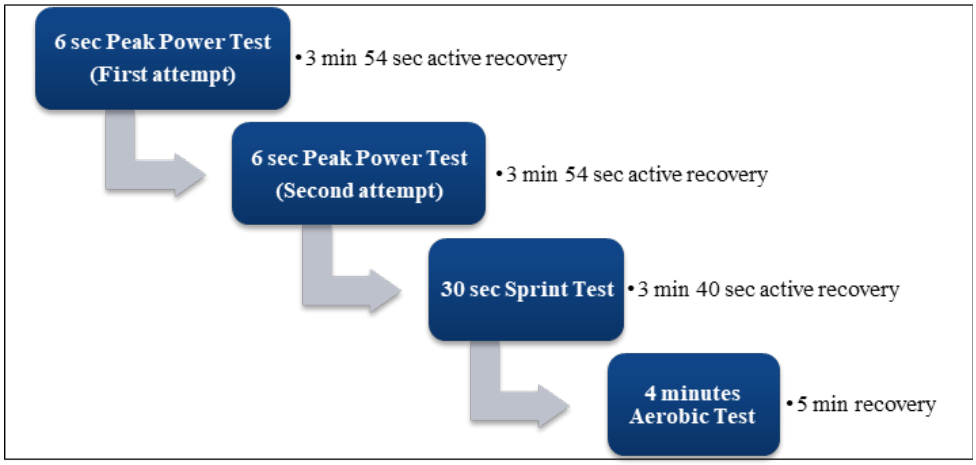

Chart 2 : World Cycling Center – Power Profile Test protocol.

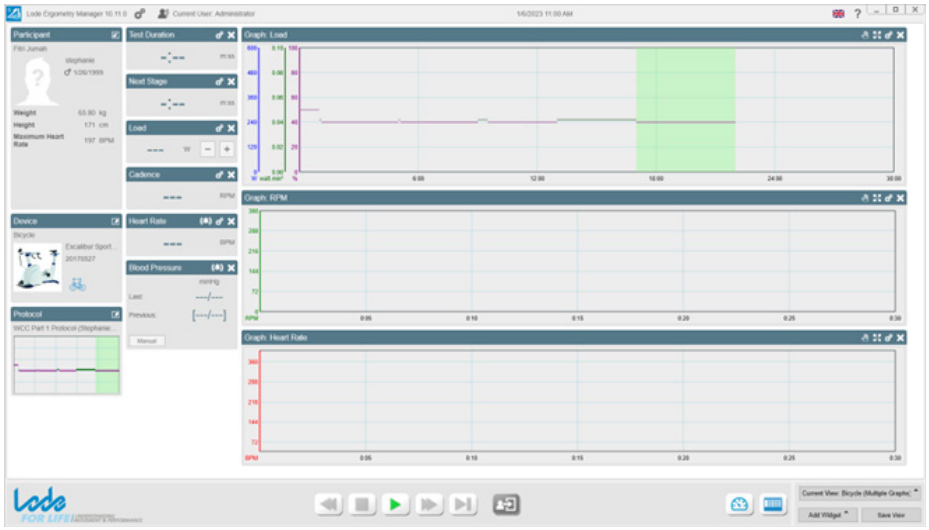

Figure 6 : Software used for the cycling performance test of Lode Ergometry Manager 10.11.1.

Heart Rate.

Measure using an Optical Heart Rate sensor (Model: Polar OH1+). The accuracy and reliability of this wearable heart rate monitor is r=.99 (Hettiarachchi et al., 2019). The data from this heart rate sensor is then immediately extracted into the Polar Beat application to avoid any errors in data collection.

Oxygen Consumption (VO2 Max)

Measured using COSMED K5. The mask can be adjusted according to each's facial built with its adjustable five-point head strap. The accuracy and reliability of this equipment are at r=0.72-0.82 (DeBlois et al., 2021). The data collected was immediately recorded in the COSMED K5 CPET (Cardiopulmonary Exercise Test) Application.

Statistical analysis

A paired sample T-test was used to compare the power output and cadence between the BPAP and UPAP outcomes. A two-way analysis of variance with repeated measures was used to compare changes in physiological capacity between the BPAP and UPAP protocols. The significance level was set at $p < 0.05$. All data

were expressed by mean ± SD.

RESULTS

Subjects. The mean age for the subjects of this study was 29.8 ± 7.7, with a mean BMI of 23.6 ± 3.0. Based on the 1RM we did for all the subjects, the mean 1RM for back squat (bilateral) movement was 83.5kg ± 15.5 and single leg split squat (unilateral) movement was 49.5kg ± 12.7. The mean baseline peak power obtained before the 1RM test was at 1671.3 watts ± 195.1 (Table 1).

Table 1: Subjects' details in mean and SD (n=50)

Variables	Mean ± SD
Age (year)	29.8 ± 7.7
Weight (kg)	66.7 ± 9.8
Height (cm)	168 ± 7.1
BMI	23.6 ± 3.0
Fat (%)	18.5 ± 5.4
1RM Bilateral (kg)	83.5 ± 15.5
1RM Unilateral (kg)	49.5 ± 12.7
Baseline Peak Power Output (watts)	1671.3 ± 195.1

Table 2: Peak Heart Rate, Average heart rate and VO2 Max reading (mean ± SD) during the 4-minute test of WCC-PPT for both BPAP and UPAP.

Variables	BPAP	UPAP	p	F
VO2 Max (ml/kg/min)	50.43 ± 7.82	50.3 ± 8.1	.448	0.93
Peak Heart Rate (bpm)	192.7 ± 7.9	192.4 ± 7.6	.326	1.078
Average Heart Rate (bpm)	174.3 ± 9.5	174.6 ± 8.2	.257	0.745

*The difference is significant at the .05 level.

Table 2 shows the comparison of Peak Heart Rate, Average Heart Rate, and VO2 Max between BPAP and UPAP during the 4-minute WCC-PPT test. The results are reported as mean ± standard deviation (SD) for each variable. There were no statistically significant differences between BPAP and UPAP in any of the measured variables, as indicated by p-values greater than 0.05. The VO2 Max was slightly higher for BPAP (50.43 ± 7.82 ml/kg/min) compared to UPAP (50.3 ± 8.1 ml/kg/min), with a p-value of 0.448 and an F-value of 0.93. Peak Heart Rate was 192.7 ± 7.9 bpm for BPAP and 192.4 ± 7.6 bpm for UPAP (p=0.326, F=1.078). Similarly, the Average Heart Rate was 174.3 ± 9.5 bpm for BPAP and 174.6 ± 8.2 bpm for UPAP (p=0.257, F=0.745). No significant differences were observed at the 0.05 level.

Table 3 compares the cycling performance variables between 85% UPAP and 85% BPAP. The study found significant differences between UPAP and BPAP in the 30-second and 4-minute tests, but not in the 6-second test. In the 30-second test, 85% of 1RM heavy strength BPAP led to a significant increase in Average Power by 13.5 watts (p=0.042, t=1.37), Average Cadence by 2.3 rpm (p=0.025, t=1.43), and Average Relative Power by 0.2 watts/kg (p=0.008, t=-1.43) compared to UPAP. For the 4-minute test, while cyclists showed improvements with BPAP, only the increase in Average Cadence by 1.5 rpm (p=0.031, t=1.45) was statistically significant.

Table 4 compares the cycling performance variables between 42.5% UPAP and 85% BPAP. The results are reported as mean ± standard deviation (SD) for each variable, with percentage differences and values provided. In terms of Peak Power Output, UPAP (42.5%) showed a higher mean (1773.95 ± 243.84 W) compared to BPAP 85% (1624.7 ± 288.33 W), with a percentage difference of 8.41% and a p-value of 0.008. Similarly, Relative Peak Power Output was significantly higher for UPAP (29.39 ± 5.26 W/kg) compared to BPAP (26.76 ± 5.06 W/kg) with a p-value of 0.004. Peak Cadence and Peak Torque were also significantly greater for UPAP (205.8 ± 14.56 rpm, 83.6 ± 5.88 Nm) than BPAP (195.95 ± 17.39 rpm, 78.92 ± 8.36 Nm), with p-values of 0.004. For the 6-second Average Power Output, UPAP exhibited a higher mean (1257 ± 130.3 W) than BPAP (1177 ± 157.62 W), with a p-value of 0.002. Similarly, the 6-second

Relative Average Power Output and 6-second Average Cadence were significantly higher in the UPAP condition (p=0.001 and p=0.015, respectively).

Conversely, for the 4-minute Average Power Output, BPAP (236.15 ± 34.85 W) was slightly higher than UPAP (228.9 ± 35.26 W), with a significant difference (p=0.041). No significant differences were observed in the 4-minute Maximum Heart Rate and 4-minute Average Heart Rate, with p-values of 0.5 and 0.152, respectively. Other non-significant variables included 30-second Peak Power Output, 30-second Average Power Output, and 4-minute VO2 Max, with p-values greater than 0.05, indicating no notable differences between the UPAP and BPAP conditions. Overall, these findings suggest that certain power and torque metrics were significantly improved under the UPAP condition at 42.5%, whereas BPAP at 85% showed better-sustained power output over the 4-minute test.

Based on the data tabulated in Table 3 and Table 4, comparing 42.5% UPAP and 85% UPAP, though no significance was recorded for average power output, 42.5% UPAP gave a greater reading for the 6-second test compared to 85% UPAP. For the 30 seconds and 4 minutes test, 85% UPAP showed a superior analysis compared to the moderate intensity heavy strength PAP. Based on the results acquired for Relative Power Output, 42.5% UPAP gave a greater reading for 6 seconds of Peak Power Output, 6 seconds of Average Power Output, 30 seconds of Average Power Output and 4 minutes of Average Power Output variables. 30 seconds Peak Power Output, on the other hand, displayed similar findings for both 42.5% UPAP and 85% UPAP. On a positive note, there was significance recorded in the Relative Peak Power Output (p=0.0001) and 6 seconds Relative Peak Power Output (0.0001) of the 42.5% of UPAP compared to 85% UPAP, as depicted in Table 3 and Table 4.

DISCUSSION

PAP can be integrated into training regimens due to its feasibility and accessibility, requiring no additional facilities or equipment beyond the standard gym or weight room resources (Lorenz, 2011). This makes PAP a practical and cost-effective strategy for enhancing athletic performance, as athletes and coaches can incorporate it into existing training programs without significant modifications or investments.

Effective scheduling and exercise selection are crucial for maximizing the benefits of PAP. Timing the PAP exercises correctly within a training session or warm-up routine ensures that athletes experience the potentiating effects at the most beneficial moments, such as just before a performance or competition. Additionally, selecting the appropriate exercises is essential to target the specific muscles and movements relevant to the athlete's sport or activity. This tailored approach helps optimize the performance-enhancing effects of PAP.

This study has established a dependable protocol for integrating heavy-strength PAP into warm-up routines. The protocol includes guidelines for appropriate loading, exercise selection, and rest intervals, tailored to accommodate athletes of varying experience levels and physical capabilities. By following this protocol, coaches and trainers can effectively incorporate PAP into their training programs, enhancing performance while minimizing the risk of injury. This approach ensures that athletes can safely and efficiently reap the benefits of PAP, leading to improved performance outcomes and overall athletic development.

The randomised crossover experimental study was conducted using a sample size of 50 athletes being tested in two different groups. The first group was tested using 85% of 1RM of UPAP and BPAP before their 6-second, 30-second, and 4-minute tests. The second

Table 3: Cycling performance variables results on 85% UPAP Vs 85% BPAP.

Variables	UPAP 85% Vs. BPAP 85%						
	UPAP (85%) Mean ± SD	BPAP (85%) Mean ± SD	Diff. (%)	Diff. (Value)	Repeated Measures ANOVA (p)	t value	F
Peak Power Output (W)	1631.8 ± 243	1652.6 ± 231.8	-1.27	-20.8	.475	-1.288	0.525
Relative Peak Power Output (W/kg)	24.53 ± 4.26	24.85 ± 4.43	-1.30	-0.32	.097	-3.77	1.137
Peak Cadence (rpm)	196.5 ± 15.3	196.6 ± 16.2	-0.05	-0.1	.924	-1.35	0.009
Peak Torque (Nm)	80.38 ± 6.46	80.83 ± 5.84	-0.56	-0.45	.281	-1.03	0.819
6sec Average Power Output (W)	1178.3 ± 136.1	1192.6 ± 129.2	-1.21	-14.3	.363	-1.36	0.853
6sec Relative Average Power Output (W/kg)	17.8 ± 2.63	18 ± 2.93	-1.12	-0.2	.527	-3.84	0.41
6sec Average Cadence (rpm)	162.6 ± 8.24	163.4 ± 9.8	-0.49	-0.8	.637	-1.10	0.227
6sec Average Torque (Nm)	69.27 ± 4.03	69.64 ± 3.88	-0.53	-0.37	.43	-0.92	0.642
30sec Peak Power Output (W)	930.17 ± 225.48	978.43 ± 153.36	-5.19	-48.26	.089	0.29	0.463
30sec Relative Peak Power Output (W/kg)	14.05 ± 3.85	14.57 ± 2.7	-3.70	-0.52	.106	-1.03	0.491
30sec Average Power Output (W)	567 ± 65.3	580.5 ± 59.4	-2.38	-13.5	*.042	1.37	4.537
30sec Relative Average Power Output (W/kg)	8.5 ± 1.03	8.7 ± 1.04	-2.35	-0.2	*.008	-1.43	8.244
30sec Average Cadence (rpm)	114.3 ± 6.9	116 ± 5.9	-1.49	-1.7	*.025	1.43	5.62
30sec Average Torque (Nm)	46.39 ± 2.67	47.26 ± 2.42	-1.88	-0.87	*.002	1.34	11.56
4min Average Power Output (W)	234.2 ± 35.25	240 ± 34.9	-2.48	-5.8	.106	1.66	2.784
4min Relative Average Power Output (W/kg)	3.5 ± 0.6	3.6 ± 0.5	-2.86	-0.1	.209	-0.53	1.651
4min Average Cadence (rpm)	73.6 ± 5.5	75.1 ± 6.2	-2.04	-1.5	*.031	1.45	5.146
4min Average Torque (Nm)	29.57 ± 2.28	30.14 ± 2.23	-1.93	-0.57	*.015	1.42	6.653
4min Maximum Heart Rate (bpm)	181.17 ± 8	181.67 ± 6.63	-0.28	-0.5	.239	-5.39	0.687
4min Average Heart Rate (bpm)	174.6 ± 8.21	174.27 ± 9.52	0.19	0.33	.373	-0.39	1.343
4min Average VO2 Max (mL/kg/min)	50.3 ± 8.1	50.43 ± 7.82	-0.26	-0.13	.448	40.53	0.931

Table 3: Cycling performance variables results on 85% UPAP Vs 85% BPAP.

Variables	UPAP 85% Vs. BPAP 85%						
	UPAP (85%) Mean ± SD	BPAP (85%) Mean ± SD	Diff. (%)	Diff. (Value)	Repeated Measures ANOVA (p)	t value	F
Peak Power Output (W)	1773.95 ± 243.84	1624.7 ± 288.33	8.41	149.25	*.008	-1.288	8.722
Relative Peak Power Output (W/kg)	29.39 ± 5.26	26.76 ± 5.06	8.95	2.63	*.004	-3.77	10.518
Peak Cadence (rpm)	205.8 ± 14.56	195.95 ± 17.39	4.79	9.85	*.004	-1.35	10.978
Peak Torque (Nm)	83.6 ± 5.88	78.92 ± 8.36	5.60	4.68	*.004	-1.03	10.557
6sec Average Power Output (W)	1257 ± 130.3	1177 ± 157.62	6.36	80	*.002	-1.36	12.725
6-sec Relative Average Power Output (W/kg)	20.83 ± 3.35	19.42 ± 3.07	6.77	1.41	*.001	-3.84	14.737
6sec Average Cadence (rpm)	166.65 ± 7.91	162.35 ± 9.52	2.58	4.3	*.015	-1.10	7.11
6sec Average Torque (Nm)	71.16 ± 4.22	68.66 ± 4.32	3.51	2.5	*.001	-0.92	15.69
30sec Peak Power Output (W)	860.75 ± 247.06	785.4 ± 166.62	8.75	75.35	.172	0.29	2.015
30sec Relative Peak Power Output (W/kg)	14.05 ± 3.79	12.9 ± 2.68	8.19	1.15	.202	-1.03	1.74
30sec Average Power Output (W)	540.6 ± 97.25	531.54 ± 74.9	1.68	9.06	.505	1.37	0.461
30sec Relative Average Power Output (W/kg)	8.86 ± 1.48	8.74 ± 1.24	1.35	0.12	.556	-1.43	0.36
30sec Average Cadence (rpm)	111.75 ± 9.84	111.15 ± 7.98	0.54	0.6	.684	1.43	0.171
30sec Average Torque (Nm)	45.43 ± 4.03	45.75 ± 4.08	-0.70	-0.32	.721	1.34	0.131
4min Average Power Output (W)	228.9 ± 35.26	236.15 ± 34.85	-3.17	-7.25	*.041	1.66	4.792
4min Relative Average Power Output (W/kg)	3.78 ± 0.644	3.89 ± 0.605	-2.91	-0.11	.051	-0.53	4.334
4min Average Cadence (rpm)	73.1 ± 5.59	74.3 ± 5.43	-1.64	-1.2	*.030	1.45	5.516
4min Average Torque (Nm)	29.37 ± 2.23	29.58 ± 2.35	-0.72	-0.21	.602	1.42	0.282
4min Maximum Heart Rate (bpm)	191.75 ± 8.06	191.75 ± 8.06	0	0	.5	-5.39	0.997
4min Average Heart Rate (bpm)	183.6 ± 7.79	184.4 ± 7.48	-0.44	-0.8	.152	-0.39	2.227
4min Average VO2 Max (mL/kg/min)	63.31 ± 9.04	61.59 ± 8.24	2.72	1.72	.288	40.53	1.197

group was tested using 85% of 1RM for BPAP and 42.5% of 1RM for UPAP (which was half the load) before their 6-second, 30-second, and 4-minute tests. This is further supported by studies done by Van Den Tillaar et al. (2019) and Schoenfeld et al. (2021) which stated that 40-60% of 1RM of unilateral heavy strength PAP is sufficient to obtain the maximum potential result of an athlete. The weight of 42.5% of 1RM is used for this study as it is exactly 50% of the 85% of 1RM and falls within the category of 40-60% of 1RM. The fast-twitch muscular fibres, which are essential for power output and speed, are activated to a sufficient degree without being too fatigued when 40–60% of 1RM is used. This range is not too high to cause premature tiredness, but it is high enough to prime the muscles and enhance motor unit recruitment (Hegedus et al., 2020).

A 6-second effort can be classified as an extremely short and explosive burst of activity (Sahlin, 2014). It falls within the realm of high-intensity, anaerobic performance. Activities that involve a 6-second effort typically include explosive movements, quick sprints, or rapid power-based exercises (Davies et al., 2015). In this study, subjects were tested for average power output, relative average power output, average cadence, and average torque during the 6-second test after performing 85% of 1RM of BPAP and UPAP. Based on the results obtained, there was no significance recorded for all the variables mentioned above.

Having said the above, there were significant differences in the average power output, relative average power output, average cadence, and average torque produced in 6 seconds following two different PAP loads: 85% of 1RM BPAP and 42.5% of 1RM for UPAP. Average power output, relative average power output, average cadence, and average torque following UPAP are higher compared to BPAP, which indicates that lightweight PAP has a significant effect on short-interval performance. 42.5% of 1RM is a lightweight PAP, which is also known as a "submaximal" PAP. This finding is consistent with a previous study done by Penichet-Tomas et al. (2020), who used 50% of 1RM load for half squat among elite male rowers, which resulted in subjects reaching a greater number of strokes ($p=0.049$) and strokes per minute ($p=0.046$).
The UPAP with 42.5% of 1RM produced higher peak power output, peak cadence, and peak torque compared to BPAP. Lightweight PAP protocols emphasize high-velocity movements that closely mimic the speed requirements of sprinting in cycling. Sprinting involves rapid force production and high cadence (Douglas et al., 2021). By training with lighter weights and focusing on explosive movements, cyclists can improve their ability to generate power quickly and efficiently during sprints. The speed specificity of lightweight PAP allows for better transfer of training adaptations to the demands of sprint-based cycling events (Vikmoen & Rønnestad, 2021).

A 30-second effort can be categorized as a brief, high-intensity burst of activity rather than a measure of endurance (Atakan et al., 2021). It falls into the realm of anaerobic metabolism, which is characterized by short-duration, intense efforts that rely on energy sources that do not require oxygen (Chamari & Padulo., 2015). During a 30-second effort, the body primarily utilizes the phosphocreatine system and anaerobic glycolysis to generate energy (Tortu et al., 2024). These energy systems can supply the body with quick bursts of power and strength but are not sustainable for longer durations due to the accumulation of metabolic by-products, such as lactic acid (Sahlin, 2014).

During the analysis of data for this 30-second test, it was discovered that there was a significant effect of 85% of 1RM of BPAP on the cyclists' average power output, relative average power output, average cadence, and average torque, compared to 85% of 1RM of UPAP. In a study done by Song et al. (2023), the author explained that performing BPAP training with 85% of 1RM can lead to an

increased neural activation of the muscles involved. The heavy load stimulates the nervous system, resulting in enhanced recruitment and activation of motor units, leading to greater force production. However, when the test was repeated in the second phase using 42.5% of 1RM for UPAP and 85% of 1RM for BPAP, there were no significant differences between UPAP and BPAP.

When comparing 85% of Unilateral PAP and 42.5% of Unilateral PAP using the independent t-test, despite the variation in results in the 6 seconds, 30 seconds, and 4 minutes, much to our surprise, 42.5% showed better results for Relative Peak Power Output and 6 seconds' Relative Average Power Output. As discussed, lighter-weight PAP protocols involve performing high-velocity movements or exercises with lower loads. These movements can prime the neural system, enhancing the activation and coordination of muscle fibres without inducing significant fatigue (Schmid et al., 2006). By targeting the activation of these muscle fibres, lighter-weight PAP can help improve the cyclist's ability to generate power output repeatedly over a long duration, such as during a long-distance cycling event (Poole et al., 2016). This can enhance endurance capabilities and maintain performance throughout the race.

Heavy-strength PAP protocols can potentially improve the average power output of cyclists by temporarily enhancing their force-generating capacity (Beato et al., 2019). Heavy strength exercises, such as squats or deadlifts, can activate a larger number of motor units and increase neural recruitment (Elgueta-Cancino et al., 2022). This increased neural drive can enhance the ability of cyclists to generate force during subsequent cycling efforts (Douglas et al., 2021). By recruiting more motor units, the muscles are better prepared to produce force and generate power during the cycling activity.

This justifies that for the 30-second test, 85% of 1RM of BPAP will provide crucial improvement in an athlete's performance. By incorporating BPAP using a high intensity, an athlete can directly target the specific muscle groups involved in their sport. This specificity can lead to improved performance in sport-specific movements and actions (Song et al., 2023).

A 4-minute test can be considered a measure of endurance, especially if it involves sustained physical or mental effort (Raghuveer et al., 2020). While it may not be classified as a long-duration endurance activity, it can still provide valuable insights into an individual's ability to maintain performance over a moderate duration (Nystoriak & Bhatnagar., 2018). It's important to note that the classification of endurance can vary depending on the specific activity and the perspective of the individual or field of study. While longer-duration activities typically come to mind when discussing endurance, shorter tests or tasks that require sustained effort can still provide valuable information about an individual's endurance capacity within that specific context (Thiel et al., 2018).

On the other hand, after analysing the data collected for the 4-minute test, it was concluded that 85% of 1RM of BPAP showed a significant difference in the average power output, torque, and cadence. 85% of 1RM of BPAP produced higher average power output, average torque and average cadence compared to 42.5% of 1RM of UPAP. This denotes that 85% of 1RM of BPAP gave a significant acute effect on the average cadence, power output, and torque of cyclists in a 4-minute testing. This can be compared with a study done by Silva et al. (2014), whereby the author used a similar weight of 75% to 85% for leg press as bilateral heavy strength PAP which showed an improvement of 6.1% in the duration to complete a 20km TT. In this study, usage of 85% of 1RM of BPAP showed an increase in power output of 3.2% among cyclists in the 4-minute test.

Long-distance cycling events often involve

intermittent bursts of high-intensity efforts (Etxebarria et al., 2019). Heavy-strength PAP can enhance recovery between these bursts by promoting better muscle recruitment, energy transfer, and overall efficiency (Ciocca et al., 2021). This improved recovery can help long-distance cyclists sustain the quality and power output of their short bursts throughout the race, even when fatigued.

CONCLUSION

In conclusion, this study demonstrates that heavy-strength PAP significantly impacts cycling performance in athletes, whether through bilateral or unilateral exercises. Significant differences were observed in the 6-second, 30-second and 4-minute WCC-PPT test. The results obtained show that lightweight PAP would benefit short interval performance whereas heavyweight PAP will be of advantage for long interval performance. This research highlights the benefits of heavy-strength PAP as a warm-up, offering evidence-based recommendations for training and injury prevention, beneficial for athletes and coaches. Proper application of the study's protocols can minimize injury risks across various age groups and weight classes. Sports associations and institutions can leverage these findings to enhance safety protocols, training programs, and talent identification processes, ultimately improving athlete performance and competition outcomes.

CONFLICT INTEREST

The author declared no conflict of interest regarding the publication of this manuscript.

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ORIGINAL ARTICLE

Short-term Outcomes of a Dedicated Pelvic Exenteration Unit in a Tertiary Hospital in Malaysia

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ABSTRACT

Background : Pelvic exenteration offers potentially curative resection for locally advanced pelvic malignancy. A dedicated unit performing this complex surgery is recommended to achieve optimal outcomes.
Objectives : The aim of this paper is to show that pelvic exenterations can be performed with acceptable oncological and safe perioperative results in an appropriately resourced specialist centre. **Methods :** Patients undergoing pelvic exenteration in the Colorectal Unit, Hospital Kuala Lumpur between January 2017 and January 2024 were included. Patients operated in the initial setup period of the unit (January 2017 – July 2020) were compared to the second half (August 2020 – January 2024) with univariate analysis. **Results :** A total of 30 patients were included, with a significant increase in the unit caseload over the study period (n = 11 versus n = 19). There was an increased use of neoadjuvant therapy and an increase in stage of disease at presentation (p = 0.014) in the second half of the study period. More complex procedures were performed in the latter period, involving both bony and pelvic side wall resections. There was no difference in complication severity (Clavien Dindo) (p = 0.257) and R0 resection was achieved in 76.7% of operated cases. **Conclusion :** The development of a dedicated pelvic exenteration unit, leads to an increase in patient volume and an increase in the complexity of the procedures performed, without compromising short term outcomes

Keywords: *Pelvic exenteration, Colorectal surgery, pelvic malignancy, Multidisciplinary care*

and safety.

INTRODUCTION

Pelvic exenteration refers to the radical multivisceral resection of tumors of the pelvis, followed by reconstruction or diversion of genitourinary and gastrointestinal function followed by repair of the pelvic defect (Brown et al., 2017, Humphries et al., 2019). Achieving R0 resection is the goal, and it is the most important predictor of survival and quality of life after surgery (Brown et al., 2017). Advances in anaesthesia, blood transfusion, medical imaging, intensive care, patient selection, as well as surgical techniques have allowed increasingly radical, higher and wider resections to be undertaken safely (Harji et al., 2013). As a result, long-term survival has become achievable with an acceptable rate of complications, when performed in dedicated units.

Despite these advances, pelvic exenteration surgery remains a major operation, with R1 resection rates remaining high, and surgery still being associated with significant morbidity and mortality. A systematic review (Platt et al., 2019) reports R0 rates to be 74% (range 41.7% - 90.2%), whilst R1 resection rates were reported to be between 7 and 46.7%, with a median of 17.5%. Globally, significant morbidity (Clavien Dindo (CD) grade 3–4) was seen in 37.8% of patients, with a 30-day mortality rate of 1.5%, and a reported median overall survival of 43 months (PelvEx Collaborative, 2017, Venchiarutti et al., 2017).

Furthermore, there is a high degree of variability in the reporting of outcomes between centres (Platt et al., 2018). Efforts of groups like the Pelvic Exenteration Collaborative (PelvEX Collaborative), which constitutes over 140 units internationally, aim to prospectively analyse and standardise the reporting and outcomes of patients undergoing pelvic exenteration to help define guidelines and optimise treatment strategies. This will lead to further standardisation between groups and drive forward research in this topic.

In this spirit, we have established our dedicated pelvic exenteration unit in January 2017. Hospital Kuala Lumpur is a tertiary hospital in the capital city of Malaysia and is well equipped to handle multidisciplinary complex cases. The aim is to streamline and improve the treatment pathway of patients requiring pelvic exenterations as well as being involved in knowledge and skills transfer through international collaboration. Patients being considered for pelvic exenteration were discussed at the respective oncology mutildisciplinary team (MDT) meeting and a collaborative team plan was made before surgery. Recently, other such centres have shown good oncological and perioperative results in the establishment phase of their dedicated pelvic exenteration unit (Traeger et al., 2019, Dickfos et al., 2018). In this paper we share our experience and compare our outcomes from the year 2017 to present.

MATERIALS AND METHODS

This study is reported using the Strengthening The Reporting of Observational studies in Epidemiology (STROBE) guidelines (von Elm et al., 2008).

Consecutive patients undergoing pelvic exenteration in Hospital Kuala Lumpur, Malaysia were included between January 2017 and January 2024. The study period is divided into two parts which we term the 'Early' period (January 2017 – July 2020), and 'Later' period (August 2020 – January 2024) for comparison of outcomes. The unit is led by colorectal surgeons and involves gynaeoncology surgeons, orthopedic surgeons, plastic reconstructive surgeons, vascular surgeons, urologist, radiologist and

oncologists. Pelvic exenteration was defined using PelvEx collaboration definitions. Total pelvic exenteration was defined as complete en bloc resection of the rectum, genitourinary viscera, internal reproductive organs, regional lymph nodes and peritoneum. Partial pelvic exenteration included those having an anterior, posterior and/or modified pelvic exenteration. Anterior pelvic exenteration included resection of the bladder with or without the internal reproductive organs (uterus, vagina, cervix, prostate, seminal vesicles). Posterior pelvic exenteration included resection of the rectum with or without the internal reproductive organs, while preserving the bladder. Modified pelvic exenteration was subdivided into those requiring lateral sidewall compartment resection with/without neurovascular resection or those requiring a bony resection (PelvEx Collaborative, 2019).

The patients are identified through the Pelvic Exenteration database, which was set up upon inception of our dedicated PE unit and the data is collected through digital and paper records retrospectively. Demographic, operative, pathological, as well as perioperative outcomes including transfusion requirements, and 30-day complications (CD grades) were recorded (Clavien et al., 2009). We also recorded the patient's length of stay in hospital, readmission rates and 30-day post operative mortality. Patients with incomplete data were excluded from the study. (Figure 1)
Patients were staged preoperatively with a combination of computed tomography, magnetic resonance imaging and positron emission tomography in selected cases. A MDT discussion is then held, and a collective decision is made for treatment with either Ip therapy (TNT), long-course chemoradiotherapy (CRT), short course radiotherapy or no neoadjuvant therapy. Following neoadjuvant therapy and subsequent restaging, the patients were then reassessed at another MDT, with a plan for surgical treatment if indications are fulfilled. Patients deemed suitable for surgery are then planned for operation involving the respective disciplines. Patients were not offered surgery if they had unresectable metastatic disease, were clinically not fit for surgery, had no surgical reconstructive options or in situations where the patients refused surgical treatment. The pathology specimen was examined by a pathologist and was defined as curative with an R0 (microscopic and macroscopic clear margins), R1 (if the margins were <1 mm) or R2 (microscopic or macroscopic evidence of an involved resection margin). Pathological stage was reported based on the American Joint Committee on Cancer, Cancer staging manual.

The analysis was performed using SPSS Statistics for Windows, Version 28.0 (IBM Corp, Armonk, NY, USA). Univariate analysis was performed for continuous variables in the data with the Mann–Whitney U or student-t test, whilst categorical variables were analysed using the $\chi 2$ or Fisher's exact test ($n < 5$). Numerical data are presented as either a mean (standard deviation, SD) or median (range), depending on its parametricity as calculated by the Shapiro–Wilk test. P-values of ≤0.05 were set as the threshold of statistical significance.

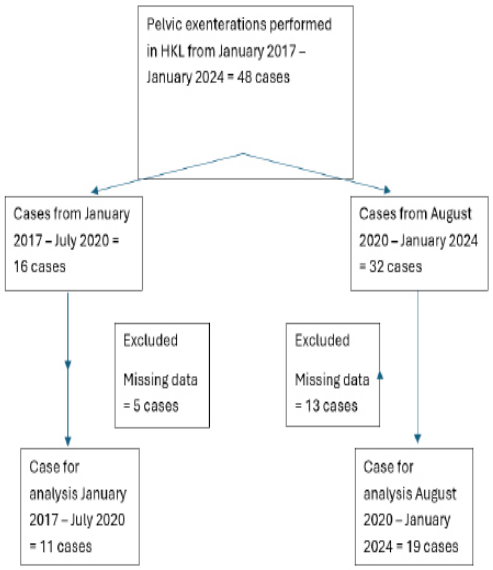

Figure 1: Flow diagram of patient selection

RESULTS

Throughout the study period (January 2017 – January 2024), a total of 48 pelvic exenterations were performed. The medical records were screened through retrospectively and were assessed for completeness of data. Any cases which had incomplete data were then excluded, leaving 30 cases for analysis (Figure 1). When looking at the number of pelvic exenterations performed year to year, it shows an increasing trend with a total of 13 cases performed in 2023 (Figure 2). The eligible cases were then divided to two separate phases, the 'early' (January 2017 – July 2020) and the 'later' (August 2020 – January 2024) whilst there were 3 cases (15.8%) performed for recurrent disease from August 2020 – January 2024 which suggests the increased complexity of the surgery performed.

There were more cases performed for Stage II and III disease in the latter period (Stage II 27.3% versus 63.2%, Stage III 27.3% versus 36.8%, P = 0.014). Looking at the utilisation of neoadjuvant therapy in the patient groups, reveals more patient undergoing neoadjuvant therapy in the later group (54.6% versus 73.7%, P = 0.237) which was not statistically significant. There appears to be an increase in the use of TNT in the later group which

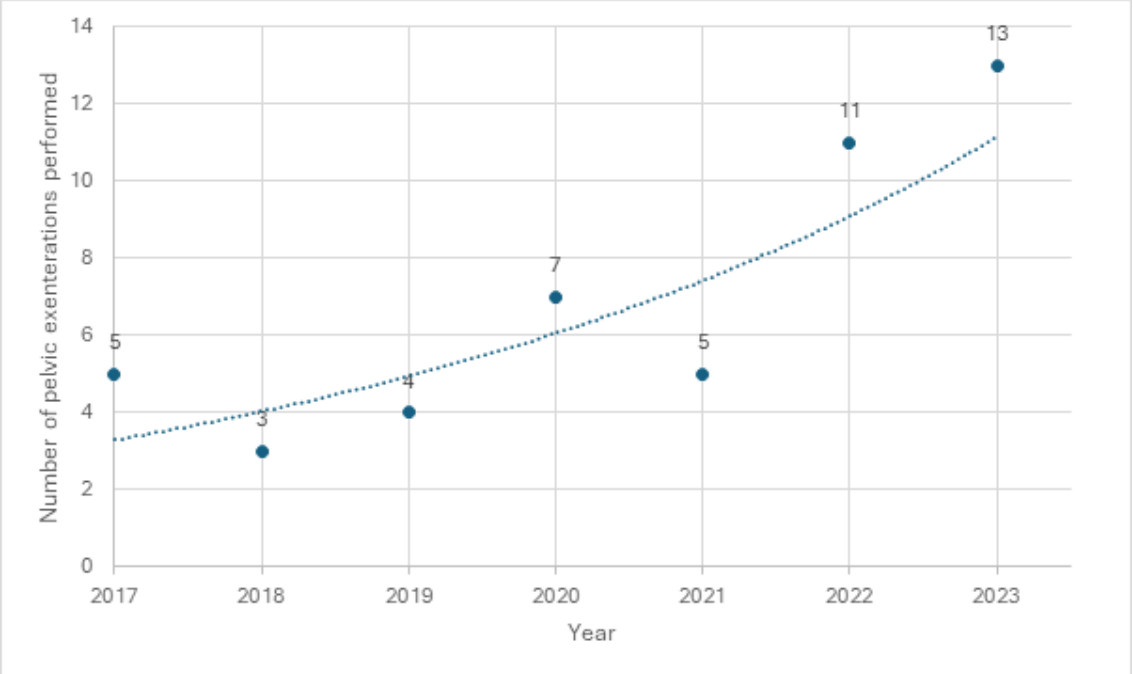

Figure 2: Number of pelvic exenterations performed in Hospital Kuala Lumpur by year 2017 - 2023

which constitutes 11 cases (36.7%) and 19 cases (63.3%).

Table 1 summarises the differences in baseline characteristics of our patients. No differences were seen in patient age, and gender. Both patient groups also showed no difference in the grade of the American Society of Anaesthesiology (ASA) grading (ASA 2 54.5% versus 78.9%, ASA 3 27.3% versus 15.8%, P = 0.33). Before August 2020 all of the cases performed were for primary malignant disease depicts the change in the worldwide trend of patient treatment throughout the 2019 COVID pandemic period. All cases were discussed in the MDT before planning for surgery.

Table 2 depicts the perioperative outcomes of the patients in our study. There were more modified pelvic exenterations after August 2020 as compared to the first half of our study period although this did not achieve statistical significance (P=0.516). From January

Table 1: Patient Demographics (presented as mean (+/-standard deviation), median (range) or number (proportion)diagram of patient selection

	January 2017 - July 2020 n = 11	August 2020 - January 2024 n = 19	p-value
Age, years	56.3 (+/-13.25)	52.3 (+/-17.74)	0.189
Gender			0.592
Male	3 (27.3)	7 (36.8)	
Female	8 (72.7)	12 (63.2)	
ASA			0.33
1	2 (18.2)	1 (5.3)	
2	6 (54.5)	15 (78.9)	
3	3 (27.3)	3 (15.8)	
4	0 (0.0)	0 (0.0)	
Primary or recurrence			0.2973
Primary	11 (100)	16 (84.2)	
Recurrence	0 (0.0)	3 (15.8)	
Palliative resection	3 (27.3)	0 (0.0)	
TNM staging			
T			
0	1 (9.1)	0 (0.0)	
1	0 (0.0)	0 (0.0)	
2	1 (9.1)	0 (0.0)	
3	2 (18.2)	4 (21.1)	
4a	0 (0.0)	2 (10.5)	
4b	7 (63.6)	13 (68.4)	
N			0.893
0	6 (54.5)	12 (63.1)	
1	3 (27.3)	4 (21.1)	
2	2 (18.2)	3 (15.8)	
AJCC staging			0.014
I	2 (18.1)	0 (0.0)	
II	3 (27.3)	12 (63.2)	
III	3 (27.3)	7 (36.8)	
IV	3 (27.3)	0 (0.0)	
Neoadjuvant Therapy			0.237
CCRT	2 (18.1)	4 (21.1)	
SCRT	0 (0.0)	1 (5.3)	
TNT	1 (9.1)	7 (36.8)	
Chemotherapy only	4 (36.4)	2 (10.5)	
No Neoadjuvant	5 (45.4)	5 (26.3)	
Discussed at MDT	11 (100)	19 (100)	

Abbreviations : ASA, American Society of Anaesthesiologists; CCRT, concurrent chemoradiation therapy; SCRT, short course radiation therapy; TNT, Total neoadjuvant therapy; MDT, multidisciplinary team

2017 – July 2020 all cases were performed as open surgery as opposed to after, where the laparascopic approach was attempted in a total of 8 cases (42%). Of this number 2 were performed via laparascopic surgery successfully while the remaining 6 cases required conversion to open surgery. There were no cases performed laparascopically prior to August 2020 and this was statistically significant (P value = 0.043).

Bone resections were performed in 2 cases (1 case S3 sacrectomy, 1 case S4 sacrectomy). Operative time was longer in

the second group (420 minutes versus 540 minutes, P value = 0.02). All of these findings is in relation to the likely increased complexity of cases performed within the unit over the years. Despite this the intraoperative blood loss remained similar (1000ml versus 1500ml, P value = 0.5) and the total ICU stay, and hospital stay were also similar between the two groups (14 days versus 15 days). There was no difference in the highest Clavien Dindo complication rates (P = 0.257).

R0 resection was achieved in 9 cases (81%) and 14 cases (74%), before and after August 2020 respectively. The difference between the two groups did not achieve statistical significance (P = 0.612).

DISCUSSION

Since the establishment of our pelvic exenteration service in January 2017, there has been a significant increase in the overall volume of surgery. This increase in volume is also matched with an increase in surgery performed for patients with increased comorbidity and more advanced stages of cancer. In addition to that, patients also underwent more technically complex surgery, with a higher rate of bone resections. There has also been an introduction of the utilisation of minimally invasive surgery in our pelvic exenterations. Despite a longer operative time, there appears to be no compromise in the outcomes of the surgery with similar R0 rates as well as no increase in the overall rates of perioperative complications. Our findings are well supported in the literature, showing that pelvic exenteration surgery which were performed by higher volume dedicated teams, leads to more complex resections, higher R0 rates and at the same time lower overall mortality rates (Venchiarutti et al., 2019).

Overall R0 resection rates in our study was 76.7% (23/30 cases). This is comparable to the worldwide R0 rates of 74% (Platt et al., 2018). Although these rates appeared to decline when comparing the earlier study period versus the latter (81% versus 74%), the decline was not statistically significant and is likely explained by the increase in case complexity and higher staging of the cases being treated.

The pattern of neoadjuvant therapy utilisation showed a trend favouring the use of TNT in the second period. Before the year 2019, our patients were offered the option of standard short course radiotherapy or long course CCRT preoperatively with the addition of adjuvant chemotherapy if clinically indicated and the patients were fit enough. Throughout the COVID pandemic, as a response to further understanding of neoadjuvant therapy options and as an adaptation to the changing patient treatment environment, patients are offered a TNT approach. This regimen involves the use of short course radiotherapy followed by a period of consolidation chemotherapy (RAPIDO regime) (Bahadoer et al 2021). At 3 years after randomisation, the cumulative probability of disease-related treatment failure was 23·7% (95% CI 19·8–27·6) in the experimental group versus 30·4% (26·1–34·6) in the standard of care group (hazard ratio 0·75, 95% CI 0·60–0·95; p=0·019) (Bahadoer et al., 2021). However, the long term follow up of the same cohort has raised questions on it effectiveness in controlling locoregional recurrences (LRR). At the 5 year follow up, LRR was detected more often [44/431 (10%) vs. 26/428 (6%); P =0.027], with more often a breached mesorectum (9/44 (21%) vs. 1/26 (4); P =0.048) possibly due to the longer waiting interval post radiation leading to more difficult surgery (Djikstra et al. 2023). The balance between improving local control and managing systemic disease will require further refinement in the treatment of rectal cancer. Although the principles of TNT appear practical and sound, further evidence are needed to prove whether this approach will contribute to long-term disease-free survival by increasing overall compliance with chemotherapy.

Table 2: Perioperative outcomes, presented as median (range), number (proportion)

	January 2017 - July 2020	August 2020 - January 2024	p - value
Exenteration Type			0.516
Total	4 (0.36)	5 (0.26)	
Anterior	2 (0.18)	2 (0.11)	
Posterior	5 (0.46)	9 (0.47)	
Modified	0	3 (0.16)	
Surgical Approach			0.043
Open	11 (1.0)	11 (0.58)	
Laparascopic	0 (0.0)	2 (0.11)	
Laparascopic convert to open	0 (0.0)	6 (0.31)	
Side wall extension	2 (0.18)	2 (0.11)	
Bony involvement	0 (0.0)	2 (0.11)	0.265
Lateral Pelvic Lymph node dissection	0 (0.0)	1 (0.05)	0.439
Type of bone resection			0.265
No	11 (1.0)	17 (0.89)	
Sacrectomy	0 (0.0)	2 (0.11)	
Extent of resection			0.612
R0 resection	9 (0.81)	14 (0.74)	
R1 resection	2 (0.19)	5 (0.26)	
Operating time, minutes	420 (208-660)	540 (330-1140)	0.02
Blood Loss	1000 (500-4000)	1500 (200-5000)	0.5
Packed cells transfused	2 (0-4)	2 (0-4)	
Anastomotic leak	0 (0.0)	0 (0.0)	
Surgical site infection	2 (0.18)	4 (0.21)	
Urinary leak	1 (0.09)	1 (0.05)	
Total ICU Stay, days	1 (0-4)	1 (0-2)	
Total Hospital Stay, days	14 (7-30)	15 (5-150)	
Readmision within 30 days	1	1	
30-day mortality	0 (0.0)	0 (0.0)	
Highest CD grade			0.257
1	7 (0.64)	7 (0.37)	
2	2 (0.18)	9 (0.47)	
3	2 (0.18)	3 (0.16)	
4	0 (0.0)	0 (0.0)	
5	0 (0.0)	0 (0.0)	

Abbreviations : CD, Clavien - Dindo

The complexity and potentially high associated morbidity of these extended surgeries necessitate meticulous planning and a MDT approach. Since the year 2022, our unit has been involved in a dedicated pelvic exenteration MDT initiated by our colleagues from Hospital Pulau Pinang. This MDT is focused on pelvic exenterations and receives interstate referrals from within Malaysia as well as the occasional international cases for discussion. The MDT process allows for a thorough review of the resectability of a tumor and discusses the possibility of other treatment adjuncts i.e radiotherapy, chemotherapy. Offering patients with advanced pelvic malignancy the reasonable chance of cure is the fundamental basis on which these radical and potentially morbid procedures are performed, and therefore ensuring appropriate patient selection processes are critical (O'Shannassy et al. 2020).

In achieving the goal of optimizing

patient outcomes, there has been a trend towards centralisation of pelvic exenteration surgery in dedicated units in tertiary hospitals. Looking at the PelvEx Collaborative data (PelvEx Collaborative, 2019). (the trend analysis from 2004 – 2015 reveals improvements in blood transfusion and resection margins status over time in high-volume centres (>20 pelvic exenterations per year) (PelvEx Collaborative, 2019). These findings reflect improvements in patient selection, better multidisciplinary input, and improvements in overall perioperative care. Several authors have also shown a reduction in 5-year overall mortality in high-volume referral centres (Aquina et al., 2016, Liu et al., 2015). Our centre currently performs 7-10 pelvic exenterations per year, and with hopes of further centralisation as well as a strengthening referral network, these numbers are likely to rise.

There are several limitations to this study. The use of retrospective data exposes the study to recall and reporting bias. The use of the retrospective database has also led to incomplete data retrieved, as seen in our study where 18 cases were excluded from the initial 48 cases. Long term outcomes were also not discussed as the analysis would be difficult given the mix of different procedures as well as different oncological approach and follow up duration between groups. A larger population and prospectively collected data would be more valuable in a future study to look at the outcomes post pelvic exenteration in our centre. Moving forward, our goal is to further improve our pelvic exenteration services and this can be achieved with the inclusion of other perioperative care processes such as psychological, the involvement of pre-rehabilitation, as well as palliative care services as part of the MDT workflow.

CONCLUSION

The development of a dedicated pelvic exenteration unit significantly improved short term patient outcomes despite more complex surgical resections and the inclusion of patients with more advanced disease. It also allows for the development of high-volume centres focused on performing pelvic exenteration surgery, which will improve the overall provision and training of locally advanced pelvic malignancy care. This supports a dedicated specialised multidisciplinary approach to locally advanced pelvic malignancy.

CONFLICT INTEREST

There is no conflict of interest declared by the authors.

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REVIEW ARTICLE

A Scoping Review: Topical Treatment of Infectious Skin Diseases with Remedial Plant Oils

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ABSTRACT

Skin infections are common ailments that affect people of all ages. One of the approaches to treating these infections is the topical application of plant oils. However, research on the therapeutic use of plant oils as remedies for skin infections remains limited. This scoping review aims to identify research gaps by assessing the types of skin infections that respond effectively to plant oil treatments. The review is conducted in three phases: the planning, conducting and analysing phases. During the planning phase, an outline of the review is developed. The conducting phase utilises the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISM) method to extract relevant data. The analysing phase involves summarising and reporting the findings. This review focuses on the usage of two classes of plant oils: essential and cooking oils, in treating bacterial, fungal, viral, and parasitic infections by evaluating their efficacies, formulations, and dosages. It also explores the methodologies, application frequencies, treatment durations, and trial limitations. Overall, tea tree oil emerged as the most commonly used treatment, with other oils showing beneficial outcomes despite variations in methodologies. Applying standardised treatment protocols, optimum sample sizes and control groups may improve the result of these studies.

Keywords: *Human study, Skin infection, Topical treatment, Plant oil, Remedy*

INTRODUCTION

Skin infections are very common, particularly among school children, hospital patients and athletes (Anderson et al., 2023; Kelly et al., 2021; Shen & Lu, 2010). They affect all age groups due to their contagious nature, spreading through direct skin contact or contaminated surfaces (van Seventer & Hochberg, 2017). Various pathogens cause these infections, including bacteria, viruses, fungi and parasites. Given the widespread nature of these diseases and various risk factors, finding effective treatments is crucial.

Synthetic drugs that are commercially available are tested and widely used as conventional treatments. However, in recent years, consumers increasingly prefer natural remedies for their affordability and fewer side effects (Karimi et al., 2015). There was also a rising trend of newly registered drugs derived from plant extracts used in treating infectious diseases since 1981 (Palmeira-de-Oliveira et al., 2013). Though plant oils have shown potential in treating skin infections (Lin et al., 2017), research remains limited, and more studies are needed.

Apart from this, the effectiveness of plant oils remains uncertain due to varying formulations and treatment regimens. For example, studies suggest antimicrobial properties of tea tree oil may treat acne (Carson et al., 2006; Kramer, 2019), but results are often inconsistent due to small sample sizes, differing application frequencies, and oil concentrations (Bassett et al., 1990; Malhi et al., 2017).

While plant oil therapy is anticipated to alleviate infections, differing methodologies may result in inconsistent outcomes. Therefore, this review aims to investigate the formulations, application frequency and treatment duration of skin infections treated with medicinally proven plant oils, encouraging further research to establish the safety and efficacy of these oils before they can be used commercially.

MATERIALS AND METHODS

Planning Phase

A research question was formulated using the PICOS framework (Population, Intervention, Comparison, Outcomes and Study) as previously reported (Eldawlatly et al., 2018). By using Table 1, the formulated research question: What is known from the human survey papers about plant oils as a treatment for skin infections as compared to synthetic drugs?

Table 1: Outlines the key elements of the PICOS framework; Population, Intervention, Comparison, Outcome, and Study, along with the corresponding keywords.

Elements	Keywords
Population	Humans
Intervention	Plant oils
Comparison	Synthetic drugs
Outcome	Treatment of skin infections
Study	Human survey

Then, the inclusion and exclusion criteria were developed as listed in Table 2. These criteria were used in the conducting phase for article screening, a process that filtered out relevant papers applicable to this study. Any paper that answered the research question and fit the inclusion criteria was included in this scoping review.

The criteria for this study included timeline, subject area, publication type and language. The timeline was set from 1980-2022 to capture trends over the past 40 years that showed a significant rise in studies on plant oils for skin infections (Figure 1). The focus was limited to human skin diseases, excluding other species as they did not answer the research question. Only human survey papers in English were included to ensure uniform data and clarity.

Table 2 : Inclusion and exclusion criteria for the review.

Criteria	Inclusion	Exclusion
Timeline	Reports within years 1980 - 2022	Reports before the year 1980
Subject area	Investigation on humans	Investigation on animals
Publication Type	Human survey articles	Systematic reviews, scoping reviews, meta-analyses, animal testing, in vitro trials

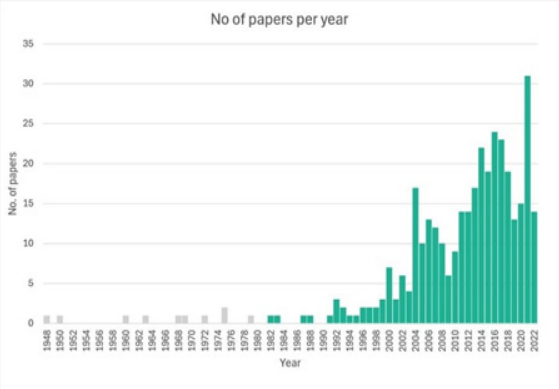

Figure 1 : The trend of studies on skin infection treatment using plant oils (1980-2022) as a source from PubMed (2022).

Conducting Phase

The research protocol was developed based on a method called Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021). It is a step-by-step guide created to assist in filtering out relevant study papers.

A reliable online database, such as PubMed, was used to search for scientific literature related to this review. PubMed was the sole database used because it offers extensive data for the period from 1980-2022. Before looking up papers on the database, a search string was constructed using a strategy mentioned previously (Zein et al., 2016) and shown in Table 3.

Table 3 : Search strategy for reviewing the use of oils in treating skin infections: This table outlines the specific search terms employed to identify relevant literature for a systematic review on the treatment of skin infections using oils. The search strategy includes combinations of terms related to "infection," "treatment," and various types of oils, such as "plant oil" and "topical oil." The use of logical operators (AND, OR) ensures a comprehensive retrieval of studies from electronic databases.

List of search terms				
"infection"		OR		"skin infection"
		AND		
		"treatment"		
		AND		
"plant oil"	OR	"oil"	OR	"topical oil"

A total of 442 articles were initially identified. After title screening based on the inclusion-exclusion criteria, irrelevant studies were excluded, leaving 64 articles for full-text assessment. These were downloaded and managed using Mendeley. After a thorough review, 50 articles were deemed relevant for this scoping review. The screening process is summarized in Figure 2.

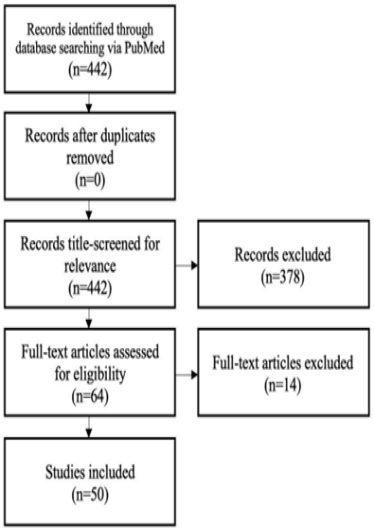

Figure 2 : Flowchart of the screening process for this study: This figure illustrates the systematic screening process used in this study to identify relevant articles on the treatment of skin infections using plant oils. The last 14 full-

text articles were excluded as they passed the initial process of title screening based on the inclusion-exclusion criteria but did not fulfil the full-text assessment .

The articles were categorised by infection type; bacterial, fungal, viral, and parasitic diseases, as outlined in Table 4. Data extraction was then performed for the final review phase.

Table 4 : Distribution of articles by disease type studied.

Disease type	No. of articles
Bacterial disease	12
Fungal disease	17
Viral disease	6
Parasitic disease	15
Total	50

Analysing Phase

This phase involved analyzing, reporting, and summarizing data to address the research question and objectives. Key details, including the type of skin infection, plant oils used, formulations, application methods, frequency, treatment duration, effectiveness, and comparison drugs, were extracted from each article. The studies were then analyzed and compared to identify knowledge gaps.

RESULTS AND DISCUSSION

1. Bacterial Diseases

Out of 12 articles reviewed on bacterial diseases, 75% of them used tea tree (Melaleuca alternifolia) oil as the treatment of choice (Table 5).

1.1. Acne vulgaris

Tea tree oil

Two different studies found that tea tree oil reduced acne lesions by half, using 5% and 20% concentrations, respectively. This indicates that higher concentrations may not enhance its effectiveness (Bassett et al., 1990, Malhi et al., 2017). However, the lack of data on application frequency in the former study leaves a gap in determining its optimal usage. Meanwhile, two double-blinded studies were conducted using 5% tea tree oil in gel and cream formulation (Enshaieh et al., 2007, Kwon et al., 2014). Despite longer treatment duration, the latter study showed poorer outcomes than the former, suggesting that cream formulation may have hindered oil penetration and reduced its efficacy. These findings highlight the importance of determining effective concentration, administration frequency, and topical formulation.

Other oils

Various formulations of ocimum (Ocimum gratissimum) oil were tested, and they found that the 2% concentration was the most effective in reducing the lesion by 50%, particularly in ethanol and cetomacrogol bases (Orafidiya et al., 2002). This suggests that increasing the concentration beyond 2% may not improve its efficacy, and the choice of vehicle plays a key role in enhancing the oil's penetration.

Another study has tested a blend of antimicrobial therapy with tea tree, lavender (Lavandula angustifolia), and jojoba (Simmondsia chinensis) oil, showing significantly reduced inflammatory lesions (Kim & Shin, 2013). The blend may work synergistically and act as an adjunct to the conventional therapy. However, further research is needed to explore the therapeutic potential of individual plant oils.

1.2. Methicillin-resistant Staphylococcus aureus (MRSA) skin infection

Tea tree oil

Edmondson et al. found that a 3.3% solution was ineffective in eliminating MRSA, while Lee et al. achieved an 87.5% elimination rate with a 10% formulation, suggesting that a higher concentration is more effective (Edmondson et al., 2011, Lee et al., 2014).

Another two studies compared tea

tree oil preparations (nasal ointments, body washes, creams) to Mupirocin as control groups. In a study of 30 participants, lesion clearance was 33% in the intervention group and 13% in the control (Caelli et al., 2001). However, a larger study with 224 participants showed 41% clearance in the intervention group and 49% in the control (Dryden et al., 2004), highlighting that small sample sizes can produce misleading results and larger studies are needed.

1.3. Staphylococcus aureus atopic dermatitis

Other oils

In studies on atopic dermatitis, they found that pure virgin coconut (Cocos nucifera) oil (VCO) had a higher recovery rate than virgin olive oil (VOO) (Verallo-Rowell et al., 2008). The lower efficacy of VOO may be due to the presence of gallate, an antioxidant that can act as a contact allergen, potentially worsening dermatitis symptoms (Holcomb et al., 2017). This underscores the importance of selecting

Table 5 : Summary of bacterial skin infections in this scoping review.

Disease	Plant oil	*Formulation	Frequency of administration (per day)	Treatment duration (days)	References
Acne vulgaris	Tea tree	5% EO in gel	?	90	Bassett et al., 1990
		20% EO in gel	2	90	Malhi et al., 2017
		5% EO in gel	2	45	Enshaieh et al., 2007
		5% EO in cream	2	60	Kwon et al., 2014
	Odium	2% EO in ethanol	2	30	Orafidiya et al., 2002
		2% EO in cetomacrogol base	2	30	
	A mixture of tea tree, lavender, jojoba	3%, 2% and 2% EO respectively with antimicrobial treatment	2	30	Kim & Shin, 2013
MRSA skin infection	Tea tree	3.3% EO in a wound wash solution	1	84	Edmondson et al., 2011
		10% EO in paraffin	1	28	Lee et al., 2014
		4% EO in nasal ointment	?	34	Caelli et al., 2001
		5% EO in body wash		5	Dryden et al., 2004
		10% EO in nasal ointment	3		
		5% EO in body wash	1		
		10% EO in cream	1		
Staphylococcus aureus atopic dermatitis	Coconut, olive	100% CO	2	28	Verallo- Rowell et al., 2008
		100% CO	2		
Erythrasma	Olive	100% ozonised CO	2	10	Ramírez-Hobak et al., 2016

*EO: essential oil; CO: cooking oil

appropriate oils to prevent adverse effects.

1.4. Erythrasma

Other oils

A paper reported that ozonated olive oil could cure all patients in 10 days (Ramírez-Hobak et al., 2016). Even though this study proved that it is effective in curing erythrasma, this trial lacks a control group, making the outcome ambiguous.

2. Fungal Diseases

A total of 17 studies were reviewed. Similar to bacterial diseases, tea tree oil is the most extensively researched plant oil for fungal diseases (Table 6).

2.1. Dandruff (commonly due to Malassezia furfur)

Tea tree oil

A study conducted to examine tea tree oil's effectiveness against fungi causing dandruff revealed that a 5% concentration in shampoo reduced lesions by 41% (Satchell et al., 2002a). While it shows potential as an antifungal treatment, tea tree oil may be more effective as an adjunct therapy rather than a standalone solution. Further research is needed to optimize its potential combinations with other active ingredients to enhance its benefits.

Other oils

Another report tested different concentrations of lemongrass (Cymbopogon flexuosus)

Table 6 : Summary of fungal skin infections in this scoping review.

Disease	Plant oil	*Formulation	Frequency of administration (per day)	Treatment duration (days)	References
Malassezia furfur (commonly caused by dandruff	Tea tree	5% EO in shampoo	Daily usage	28	Satchell et al., 2002a
	Lemongrass	10% EO in hair tonic	Twice daily	14	Chaisripipat et al., 2015
Tinea unguium	Tea tree	100% EO	Twice daily	180	Buck et al., 1994
		5% EO in cream	Thrice daily	56	Syed et al., 1999
	Sunflower	100% ozonised CO	Twice daily	90	Menendez et al., 2011
	Eucalyptus	100% EO	?	120	Bramston et al., 2015
Tinea versicolor	Artemisia	5% EO in cream	Twice daily	14	Mansouri et al., 2010
		5% EO in cream	Twice daily	14	Rad et al., 2008
		3% EO in cream	Twice daily	14	Khosravi et al., 2009
	Lemongrass	0.125% in cream	Twice daily	40	Carmo et al., 2013
		0.125% in shampoo	Thrice weekly		
Tinea pedis, corporis and cruris	Bitter orange	25% EO in emulsion	Thrice daily	28	Ramadan et al., 1996
	Eucalyptus	1% EO in ointment	Twice daily	21	Shahi et al., 2000
Tinea pedis, corporis and versicolor	Thyme	3% EO in cream	Twice daily	28	Shimelis et al., 2012

*EO: essential oil; CO: cooking oil

oil in tonic (Chaisripipat et al., 2015) and revealed that the 10% concentration was the most effective in reducing dandruff by 81%. The results indicate that the oil's antifungal properties are likely concentration-dependent, with optimal efficacy and tolerability at specific levels. The reduced effectiveness at higher concentrations could be due to potential irritation or diminished absorption. Identifying the best concentration is crucial for maximising benefits and minimising adverse effects.

2.2. Tinea unguium

Tea tree oil

A study has documented a 60% resolution rate with pure tea tree oil, while another report achieved an 80% cure rate using only 5% formulation (Buck et al., 1994, Syed et al., 1999). Differences in oil concentration, treatment duration (180 vs. 56 days), and control drugs used (clotrimazole vs. butenafine) complicate these comparisons, with butenafine showing better cure rates than clotrimazole in other studies (Singal et al., 2005). These variations highlight the need for standardization when evaluating tea tree oil's effectiveness.

Other oils

Application of ozonated sunflower oil (OLEOZON®) with 2% ketoconazole cream revealed 91% of patients were cured, as compared to 14% in the control group. This outcome could be due to enhanced antimicrobial properties from ozonation (Menendez et al., 2011). Furthermore, pure eucalyptus (Eucalyptus pauciflora) oil also showed a high clearance rate for superficial toenail infections, though the application frequency was not specified (Bramston et al., 2015). The latter study emphasizes the need to assess its effectiveness in more severe cases, especially those involving the nail matrix.

2.3. Tinea versicolor

Artemisia (Artemisia sieberi) oil

Two trials found that a 5% concentration in cream achieved over 80% cure rates within a 14-day treatment period, indicating high effectiveness (Mansouri et al., 2010; Rad et al., 2008). In contrast, another study used a 3% concentration, achieving a lower 70% cure rate, suggesting that a stronger formulation is more effective (Khosravi et al., 2009).

Other oils

A study tested 0.125% lemongrass oil in both cream and shampoo formulations for treating tinea versicolor (Carmo et al., 2013). While lemongrass oil shows potential as a natural alternative, it is less effective than ketoconazole. More research is needed to improve its efficacy at par with conventional treatment.

2.4. Tinea pedis

Tea tree oils

Two studies on tinea pedis used tea tree oil treatments (Tong et al., 1992, Satchell et al., 2002b). The former used a 10% tea tree oil cream, while the latter applied 25% and 50% tea tree oil in an ethanol-polyethylene glycol solution. Although clinical cure rates showed no significant difference, the 50% tea tree oil achieved the highest mycological cure rate of 64%, indicating greater effectiveness at higher concentrations.

Other oils

Ozonated sunflower (Helianthus annuus) oil was applied for six weeks and achieved a 75% cure rate (Menéndez et al., 2002), while 6% coriander (Coriandrum sativum) oil in ointment resulted in 71% cure after four weeks (Beikert et al., 2013). Coriander oil was more effective in delivering results within a shorter period, though both oils proved to be effective treatments.

2.5. Other forms of tinea

Other oils

Two reports documented treating tinea pedis, corporis, and cruris with essential oils. The first study found that a 25% bitter orange (Citrus aurantium) oil achieved an 80% cure rate (Ramadan et al., 1996), while the second report

revealed a 60% cure rate using a 1% eucalyptus oil (Shahi et al., 2000).

Meanwhile, Shimelis et al. tested a 3% thyme (Thymus schimperi Ronniger) cream to tinea pedis, corporis, and versicolor, achieving a 67% cure rate (Shimelis et al., 2012). This suggests that few options of plant oils can be used to treat these diseases effectively.

Table 7 : Summary of viral skin infections in this scoping review.

Disease	Plant oil	*Formulation	Frequency of administration (per day)	Treatment duration (days)	References
Molluscum contagiosum	Tea tree	75% EO in iodine	2	30	Markum & Baillie, 2012
	Lemon myrtle	10% EO in olive oil	1	21	Burke et al., 2004
	Sandalwood	In soap	2	84	Haque & Coury, 2018a
Common warts	Tea tree	100% EO	1	12	Millar & Moore, 2008
	Sandalwood	100% EO	2	84	Haque & Coury, 2018b
Herpes labialis	Tea tree	6% EO in gel	5	9	Carson et al., 2001

*EO: essential oil; CO: cooking oil

3. Viral Diseases

Six articles reported on viral diseases, with all of them utilising essential oils, either in their pure or blended forms (Table 7).

3.1. Molluscum contagiosum

Pure oils

One study tested three topical treatments for molluscum contagiosum: pure tea tree oil, pure iodine, and a combination of tea tree oil and iodine (Markum & Baillie, 2012). The combined treatment, which contained 75% tea tree oil in iodine, was the most effective, reducing lesions in 80% of subjects after twice-daily application for a month, indicating that combined formulation with plant oil may improve the disease outcome.

Blended oils

Burke et al. (2004) compared the effectiveness of 10% lemon myrtle (Backhousia citriodora) in olive oil to olive oil alone, finding that more than half of the subjects using the former blend achieved a 90% reduction in symptoms, while none in the olive oil group (Burke et al., 2004). This demonstrates that lemon myrtle in olive oil is more effective. A more recent study tested sandalwood (Santalum album) oil in soap, finding a 90% cure rate after 12 weeks of use (Haque & Coury (2018a). However, this study lacked a control group, limiting the ability to compare the results directly.

3.2) Common warts

Pure oils

In the study of warts, the first report applied pure tea tree oil once daily for 12 days, achieving complete resolution (Millar & Moore, 2008). The second report used pure sandalwood oil, with twice-daily application for 12 weeks, resulting in an 80% cure rate (Haque & Coury, 2018b). Although tea tree oil showed greater success, both studies had small sample sizes and lacked control groups, highlighting the need for larger, controlled trials to validate these results.

3.3. Herpes labialis

Blended oils

A single trial investigated the application of 6% tea tree oil gel for herpes labialis until herpes simplex virus DNA tested negative for two consecutive days (Carson et al., 2001). Results showed no significant difference compared to the placebo, likely due to the small sample size of 18 patients.

4. Parasitic Diseases

There are 15 studies involving essential and cooking oils as a treatment for parasitic skin diseases (Table 8).

Table 8 : Summary of parasitic skin infections in this scoping review.

Disease	Plant oil	*Formulation	Frequency of administration (per day)	Treatment duration (days)	References
Pediculosis	Citronella	3.7% EO in emulsion	Six times weekly	120	Mumcuoglu et al., 2005
	Mixture of tea tree, lavender	10% and 1% EO respectively in pediculicide	Once weekly	14	Barker & Altman, 2010
	Mixture of eucalyptus, lemon tea tree	11% and 1% EO respectively in pediculicide	Once weekly	14	Greive & Barnes, 2018
	Coconut	In shampoo	Once weekly	7	Connolly et al., 2008
		1% CO in shampoo	Once weekly	8	Burgess & Burgess, 2020
	Olive	In soap	Once weekly	7	Soler et al., 2017
	Mixture of coconut, anise, ylang ylang	In pediculicide	Once weekly	15	Mumcuoglu et al., 2002
Scabies	Lippia	20% EO in paraffin	Once daily	5	Oladimeji et al., 2000
		20% EO in glyceryl monostearate/sodium lauryl sulphate emulsion	Once daily	5	Oladimeji et al., 2005
Demodex blepharitis	Tea tree	50% EO in mineral oil	Once weekly	30	Gao et al, 2007
		50% EO in mineral oil	Once weekly	30	Gao et al., 2005
		50% EO in mineral oil	Once weekly	30	Koo et al., 2012
		5% EO in ointment	Twice daily	30	Gao et al., 2012
		In face wash	Once daily	30	Murphy et al., 2018
Tungiasis	Neem	20% EO in coconut oil	Every other day	3	Elson et al., 2019

*EO: essential oil; CO: cooking oil

4.1. Pediculosis

Essential oils

The first trial demonstrated a 3.7% citronella (Cymbopogon nardus) oil emulsion against a control emulsion without citronella (Mumcuoglu et al., 2005). After daily spraying for six days a week over four months, the citronella emulsion was effective, with only 12.4% of subjects remaining infested compared to 33.7% in the control group.

The second trial evaluated a combination of 10% tea tree and 1% lavender oils (TTO/LO) (Barker & Altman, 2010), achieving a 97.6% cure rate, similar to a commercially available 'suffocation' lotion. However, another treatment, pyrethrins-piperonyl butoxide mousse only cured 25% of subjects.

Meanwhile, the third trial tested a combination of 11% eucalyptus oil and 1% lemon tea tree (Leptospermum petersonii) oils

(EO/LTT) (Greive & Barnes, 2018), obtaining an 83% cure rate, compared to 36% with the mousse. All trials demonstrated the effectiveness of essential oil treatments.

Vegetable cooking oils

Three studies tested cooking oils for their antifungal properties: two on coconut oil shampoos and one on olive oil soap. Coconut oil shampoos showed varied results, with one study reporting a 59% cure rate (Connolly et al., 2008) and another 39% (Burgess & Burgess, 2020), despite using similar methods. Meanwhile, the study on olive oil soap (Brand: Inex) demonstrated a 76% cure rate, close to the 79% cure rate of the established product, Paranix (Soler et al., 2017), suggesting olive oil soap is comparably effective.

Combination of both oil types

A single study examined a combination of essential and vegetable oils in the product, Chick-Chack, which contains coconut, anise (Pimpinella anisum) and ylang ylang (Cananga odorata) oil against ParaPlus spray, a known pediculicide, as the control (Mumcuoglu et al., 2002). Both were applied according to manufacturer instructions, with Chick-Chack sprayed thrice at five-day intervals, and ParaPlus twice at 10-day intervals. The study found no significant difference, with both products achieving a 92% cure rate.

4.2. Scabies

Essential oils

Two studies tested lippia (Lippia multiflora) oil against benzyl benzoate for scabies treatment. The first study found that 20% lippia oil diluted with paraffin achieved a 100% cure rate over five days (Oladimeji et al., 2000). The second study, using a 20% lippia oil in emulsion, showed an 80% cure rate in the same period (Oladimeji et al., 2005). Both studies confirmed the effectiveness of 20% lippia oil in treating scabies.

4.3. Demodex blepharitis

Essential oils

Three trials tested 50% tea tree oil solution as a weekly lid scrub over four weeks, using either cotton tips or bare fingers. All studies showed positive outcomes with no significant differences in application methods (Gao et al, 2007; Gao et al., 2005, Koo et al., 2012). Additionally, two studies explored tea tree oil in skincare products; a 5% tea tree oil ointment resulted in 67% patient improvement after four weeks of twice-daily use (Gao et al., 2012), and 'Dr Organic Tea Tree Face Wash' also showed positive results after nightly application for four weeks (Murphy et al., 2018).

4.4. Tungiasis

Combination of both oil types

A study compared the effects of neem (Azadirachta indica) in coconut oil with standard potassium permanganate therapy. The oil mixture was applied on days 1 and 3, while the standard treatment was only on day 1. Although the oil mixture was not more effective overall, it killed an average of 40% of the fleas (Elson et al., 2019). Further trials using different dosages and methods may improve the outcome.

CONCLUSION

This review summarizes 42 years of research on using plant oils to treat skin infections, with tea tree oil being the most studied and widely used due to its healing properties. Research during this period investigated various formulations, application frequencies, and treatment durations, leading to promising but varying results. Some studies indicated the need for higher concentrations, while others required less. Overall, plant oil therapies generally showed positive outcomes, though certain diseases responded better when combined with synthetic treatments. Future research should focus on optimizing formulations and standardizing administration to obtain consistent results. It is also best to compare this alternative therapy to conventional treatment, while also evaluating the safety of higher oil concentrations.

Despite this, few studies reported in this scoping review did not include a control group; in which having a control group is crucial before the product can be prescribed commercially. Another important observation in these studies was the use of a small sample size that may have skewed the results. The challenge lies in recruiting enough participants for the mentioned studies, as it was difficult to achieve a sizable sample with the studied skin infection. To solve this issue, collaboration can be done with multiple research centres and study sites, which can help in recruiting more patients.

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CONFLICT OF INTEREST

The author declares that the manuscript produced in the absence of any financial or commercial relationships could be construed as a potential conflict of interest.

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REVIEW ARTICLE

Impact of COVID-19 towards antibiotic consumption in a major specialist hospital: A non-COVID-19 hospital perspective

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ABSTRACT

The Coronavirus disease 2019 (COVID-19) pandemic heavily affected healthcare services and medication supply. Literatures showed that the consumption of antibiotics was significantly increased during the pandemic especially in COVID-19 hospitals, however, little is known about the collateral impact of the pandemic in non-COVID-19 healthcare settings, such as Hospital Queen Elizabeth II (HQEII) based in Malaysia. This study aimed to compare the prevalence of antibiotic consumption before (2018 & 2019) and during (2020 & 2021) the pandemic, and to explore its impact on antibiotic-acquired cost and bacterial resistance. This is a descriptive observational study where the antibiotic consumption from 1st January 2018 to 31st December 2021 in HQEII was reviewed. The antibiotics selected were Meropenem, Vancomycin, Piperacillin-tazobactam, Ceftazidime and Ceftriaxone. The antibiotic consumption, antibiotic-acquired cost and cases of multidrug resistant organism (MRO) before (2018 & 2019) and during (2020 & 2021) the COVID-19 pandemic were compared, with combined 2 years data for comparison. The overall consumption of the selected antibiotics significantly increased by 45.2% (34.8 vs 50.5, p<0.001) during the COVID-19 pandemic. Intensive care unit had the highest increase in antibiotic consumption (+114.3%, p<0.001). There was a raising trend for the use of Vancomycin, Meropenem, Ceftazidime and Piperacillin-Tazobactam (p<0.005). All

these contributed to a significant increase in antibiotic-acquired cost by 64.4% during the COVID-19 pandemic (RM909,898.80 vs RM1,486,791.20, p<0.001). Notably, cases of multidrug resistant organisms also increased, especially MRO Acinetobacter (+197%) and Carbapenem-resistant Enterobacterales (+92%). High antibiotic consumption, antibiotic-acquired cost and MRO cases were observed in non-COVID-19 healthcare setting during the pandemic, but the factors contributing to the surge were not explored in this study.

INTRODUCTION

The Coronavirus disease 2019 (COVID-19) pandemic had led to national quarantine and movement restrictions in Malaysia on 18th March 2020. Local hospitals faced challenges to care for the exponentially growing number of infected patients while running short of ventilators and medical equipment. Most non-COVID-19 healthcare services were interrupted, reducing patients' accessibility to receive usual treatment and monitoring (Assefa et al., 2021). The surge in COVID-19 patients and other critically ill patients also led to shortage of medication supplies due to higher demand during the pandemic (Shuman et al., 2020).

Previous literatures showed that there was a significant upshift in the antibiotic usage during the COVID-19 pandemic, especially Cephalosporins (Hussein et al., 2022; Nandi et al., 2023). Although secondary bacterial infection in COVID-19 patients was relatively uncommon, empirical antibiotic treatment was still often prescribed (Granata et al., 2022). In such cases, guidelines warned that the overuse of antibiotic increases the risk of antimicrobial resistance (Living Guidance for Clinical Management of COVID-19: Living Guidance, 2021). While most studies were done in COVID-19 isolation hospitals, only few revealed the collateral impact of the pandemic towards antibiotic consumption in non-COVID-19 healthcare settings (da Silva et al., 2021).

Hospital Queen Elizabeth II (HQEII) is a non-COVID-19 hospital based in Sabah, Malaysia. This study aims to investigate and compare the consumption of Vancomycin, Meropenem, Ceftazidime and Piperacillin-Tazobactam in HQEII before and during COVID-19 pandemic. This study also explores the antibiotic-acquired cost and bacterial resistance pattern as a result of changes in antibiotic consumption, if any. The results of this study would be useful in implying whether there is a need to monitor and further promote the optimisation of antibiotic use.

METHODS

This is a descriptive observational study where the antibiotic consumption from 1st January 2018 to 31st December 2021 in HQEII was reviewed. The selected antibiotics were Meropenem, Vancomycin, Piperacillin-tazobactam, Ceftazidime and Ceftriaxone. These antibiotics were selected because their consumption exceeded the upper limit of the national antimicrobial usage in 2020. In our setting, all antibiotics that are prescribed to patients will be transcribed into pharmacy supply database. The number of vials of antibiotics was identified through pharmacy supply database. The antibiotic consumption was then converted into defined daily dose (DDD) by dividing the number of grams supplied with the 2019-2020 ATC/DDD index assigned by the World Health Organisation (WHO) (WHOCC - ATC/DDD Index, n.d.). For combination antibiotics, the assigned DDD is based on the main principal drug rather than the whole combination product. For example, the DDD for piperacillin-tazobactam will only take into account the grams of piperacillin as the main principal drug. The DDD was presented as the DDD per 1000 patient days. Table 1 shows the antibiotics selected for this study and their corresponding DDDs.

Table 1: Antibiotics WHO ATC/DDD index 2020

Antibiotic	WHO assigned DDD index
Meropenem	3
Vancomycin	2
Piperacillin-tazobactam	14
Ceftazidime	4
Ceftriaxone	2

The antibiotic-acquired cost was calculated by multiplying the number of vials of the antibiotics to the cost of each vial, at the time of purchase.

organisms. Specifically, DDD was be used to compare for the antibiotic consumption. The independent T-test was used to compare the antibiotic consumption and cost before (2018 & 2019) and during (2020 & 2021) the COVID-19 pandemic as the data was normally distributed.

Ethics Statement

This study was approved by the Medical Research and Ethics Committee with the identification code NMRR ID-22-00863-AET, which complies with the Declaration of Helsinki.

Table 2: The antibiotic consumption (Vancomycin, Meropenem, Piperacillin-tazobactam, Ceftazidime and Ceftriaxone) before and during COVID-19 pandemic as measured by DDD per 1000 patient days in HQEII

Antibiotics	DDD Before COVID-19 Pandemic (2018 & 2019)	During COVID-19 Pandemic (2020 & 2021)	% of Change	P-value
Vancomycin	6.85	14.23	+107.75	<0.001
Meropenem	19.59	43.18	+120.40	<0.001
Piperacillin-Tazobactam	49.50	67.51	+36.39	0.003
Ceftazidime	39.09	65.19	+66.79	<0.001
Ceftriaxone	58.74	62.28	+6.03	0.579

The number of cases of resistant organism before and during pandemic were obtained through the microbiology department report. The multidrug-resistant organisms included in this study were methicillin-resistant Staphylococcus aureus (MRSA), Acinetobacter sp. MDR, extended spectrum beta lactamases-producing organism (ESBL), Carbapenem-resistant Enterobacterales (CRE) and Carbapenem-resistant Pseudomonas.

Statistical analysis

The data was analysed using SPSS version 19. Descriptive analysis, i.e., number and percentage, was used to describe the antibiotic consumption, antibiotic-acquired cost and cases of multidrug resistance

RESULTS

Data was analysed for the period of January 2018 to December 2021. There were 60412 registered patients on the selected antibiotics in 2018 increasing to 61,074, 65,573, 80,894 in 2019 until 2021 respectively.

Antibiotic consumption

The antibiotic consumption showed an overall significant increase of 45.2% (34.8 vs 50.5, $p<0.001$) during the pandemic. The antibiotic consumption before and during COVID-19 pandemic are shown in Table 2.

Among all departments, Intensive Care Unit (ICU) showed the highest increase

in antibiotic consumption during the pandemic (144.3%). Individually, ICU also showed the highest increase in consumption for Vancomycin (1749.7%), Piperacillin-tazobactam (109.2%) and Ceftriaxone (70.8%). Interestingly, orthopaedics showed the

Table 3: The comparison of antibiotic consumption as measured by DDD per 1000 patient days before and during COVID-19 pandemic among different departments in HQEII

Department	DDD Before COVID-19 Pandemic (2018 & 2019)	During COVID-19 Pandemic (2020 & 2021)	% of Change	P-value
ICU				
Vancomycin	1.55	28.61	+1749.70	<0.001
Meropenem	71.02	192.53	+171.09	<0.001
Piperacillin-Tazo-bactam	76.81	160.70	+109.22	<0.001
Ceftazidime	19.30	64.00	+231.63	<0.001
Ceftriaxone	45.94	78.48	+70.83	0.044
Overall	42.92	104.86	+144.30	<0.001
Medical-based				
Vancomycin	3.93	10.57	+168.67	0.002
Meropenem	25.37	55.98	+120.68	<0.001
Piperacillin-Tazo-bactam	52.26	68.98	+31.48	0.007
Ceftazidime	67.76	116.53	+71.96	<0.001
Ceftriaxone	89.77	116.58	+29.87	0.035
Overall	47.81	73.73	+54.18	<0.001
Surgical-based				
Vancomycin	3.35	12.41	+270.59	<0.001
Meropenem	10.96	36.16	+229.79	<0.001
Piperacillin-Tazo-bactam	46.43	54.10	+16.53	0.327
Ceftazidime	5.76	21.49	+273.31	<0.001
Ceftriaxone	52.89	45.27	-14.42	0.445
Overall	23.88	33.89	+41.91	0.002
Orthopaedic				
Vancomycin	21.68	18.74	-13.55	0.654
Meropenem	4.23	14.99	+254.66	<0.001
Piperacillin-Tazo-bactam	41.83	73.91	+76.69	<0.001
Ceftazidime	8.80	47.16	+436.15	<0.001
Ceftriaxone	9.87	7.01	-28.99	0.527
Overall	17.28	32.36	+87.28	<0.001

highest increase for Ceftazidime (436.2%) and Meropenem (254.7%).

Cost of antibiotic consumption

The total cost of antibiotic consumption before COVID-19 pandemic was RM909,898.80 and later increased by 63.2% to RM1,486,791.20 during COVID-19 pandemic. Moving to individual antibiotics, Meropenem showed the highest increase in cost (140.98%), followed by Vancomycin (89.12%), Ceftazidime (89.12%), Piperacillin-tazobactam (43.69%) and Ceftriaxone (16.36%). The total cost of antibiotics used are shown in Table 4.

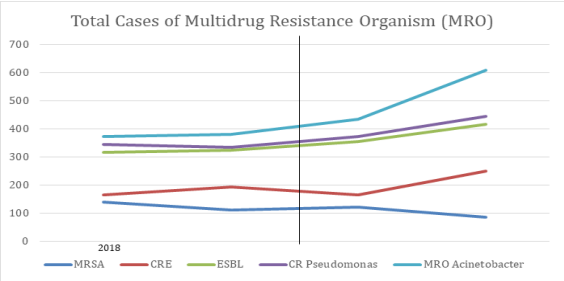

Figure1: The total cases of multidrug resistance organism before and during COVID-19 pandemic

Table 4: The comparison of total cost of antibiotics used before and during COVID-19 pandemic

Types of antibiotics	Total cost of antibiotics used (RM)			
	Before COVID-19 Pandemic (2018 & 2019)	During COVID-19 Pandemic (2020 & 2021)	% of change	P- value
Piperacillin-Tazobactam	218,854.40	314,478.70	+43.69	<0.001
Ceftazidime	206,698.15	364,395.60	+76.29	<0.001
Vancomycin	87,374.40	165,246.50	+89.12	<0.001
Ceftriaxone	251,936.40	293,159.00	+16.36	0.006
Meropenem	145,035.45	349,511.40	+140.98	<0.001
Overall	909,898.80	1,486,791.20	+63.40	<0.001

Bacterial resistance pattern

There were increases in total cases of MRO Acinetobacter, Carbapenem-resistant Pseudomonas, ESBL (*K. pneumonae, K. oxytoca, E. coli & Proteus Mirabilis*) and Carbapenem-resistant Enterobacterales. However, the total cases of Methicillin-resistant *Staphylococcus aureus* (MRSA) showed a decreasing trend during COVID-19 pandemic. The total cases of multidrug resistance organism are shown in Figure 1.

DISCUSSION

During COVID-19 pandemic, all of the selected antibiotic consumption, except Ceftriaxone, showed a significant increase in HQEII.

Specifically, Meropenem showed the highest increase in consumption among all antibiotics. Among all departments, ICU showed the highest increase in antibiotic consumption particularly for Vancomycin, Piperacillin-tazobactam and Ceftriaxone. Similar findings were observed in Spain with 11.5% increment on antibiotic use during Covid-19 pandemic (Gonzalez-Zorn, 2021). A study by Silva ARO et al observed similar outcome in ICU settings for Brazilian hospitals with the overall antimicrobial consumption increased from January-2019 to December-2020 by 11.2% (Silva et al., 2021). ICU is catered for critically ill patients, including those with severe bacterial infections, which may explain its high consumption of antibiotics. However,

the indication for the use of each antibiotic was not explored in this study. Hence, while there was an obvious increasing trend during the COVID-19 pandemic, the rationale for high consumption of these antibiotics was unclear.

The significant increase in antibiotic consumption during the COVID-19 pandemic also led to a significant increase in total cost of antibiotics by 63.2%. Meropenem contributed with the highest increase in cost. Reducing the consumption of antibiotics can be a measure to lower the cost of antibiotics use. This can be done by de-escalating these antibiotics to a less expensive narrow-spectrum antibiotic and by reducing the duration of antibiotic therapy (Cheah et al., 2021).

With the increased consumption of antibiotics, there were also increases in total cases of multidrug resistant organisms (MRO), especially MRO Acinetobacter and Carbapenem-resistant Enterobacterales. Similar increase in MRO cases was also observed in an acute care hospital in Brazil, whereby the overall incidence of multidrug resistance (MDR) infections increased by 23% ($P < .005$) during COVID-19 (Polly et al., 2022). Interestingly, there was a disproportionate MRSA case even with an increase in vancomycin usage. As mentioned earlier, the rationale of high antibiotic consumption was not explored in this study to fully understand the correlation between antibiotic consumption and multidrug resistant organisms. It is widely agreed that the overuse of antibiotics is the main driver in the development of antimicrobial resistance. However, other factors such as the misuse of antibiotics, i.e., inappropriate antibiotic choice and duration, may also play a role in accelerating antimicrobial resistance (Antimicrobial Resistance, n.d.).

HQEII was designated as the main non-COVID-19 referral centre in west coast Sabah during the pandemic. Some sub-specialities from COVID-19 hospitals were transferred to HQEII, increasing the patient load by a bed occupancy rate of 7.4%. Also, patients referred to HQEII from other facilities were generally in a more severe disease state. This may lead to an increase in antibiotic consumption during the pandemic.

Earlier in the year 2017, Antimicrobial Stewardship (AMS) programme was introduced in HQEII to enforce the appropriate use of optimal antimicrobial drug regimen. During COVID-19 pandemic, there was an interruption of AMS service which was carried out twice weekly and the round was withheld from March 2020 until October 2021. The AMS team was also redeployed to manage the pandemic, resulting in the lack of antibiotic surveillance. Similar to previous literature findings, the results of this study suggest that AMS programme is imperative towards the vigilant use of antibiotics and to combat antimicrobial resistance (Elshenawy et al., 2023).

CONCLUSION

High antibiotic consumption, antibiotic-acquired cost and multidrug resistance organism (MRO) cases were observed in non-COVID-19 healthcare setting during the pandemic. However, the factors contributing to the surge were not explored in this study. Our suggestion for future studies would be to include the factors contributing to antibiotic consumption as well as the bacterial resistance pattern.

DECLARATION OF INTEREST

The authors declare no conflict of interest.

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CASE REPORT

Subcutaneous Mycoses on The Face of A Child: A Case Report

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ABSTRACT

Skin infections is a common presentation at primary healthcare clinics. It may be caused by a variety of pathogens, including viruses, bacteria, fungi, or parasites. The most common skin infections are caused by bacteria, namely Staphylococcus aureus and Group A beta-haemolytic streptococci. Fungal infections, particularly subcutaneous mycoses, may exhibit similar clinical features as bacterial infections. In this case report, we highlight the importance of considering subcutaneous mycoses as a differential diagnosis for patients presented with skin infections, especially if the condition did not improve with antibiotic. This case report also emphasised the importance of considering the potential side effects of systemic antifungal medications before initiating the treatment in children. Accurate diagnosis through culture testing is essential to guide the treatment, rather than relying solely on empirical treatment based on clinical symptoms.

INTRODUCTION

The skin serves as the body's main external barrier, and is vulnerable to infections caused by bacteria, viruses, and fungi (Ma et al., 2021). Fungal infections affecting the cutaneous and subcutaneous tissue are becoming more common, affecting both healthy and weakened immune systems individuals. Cutaneous and subcutaneous fungal infections are caused by

a wide range of fungi, including molds, yeasts, and dimorphic fungi, which can be either pathogenic or opportunistic in nature (Ma et al., 2021). Subcutaneous fungal infections may involve deeper layers, such as the dermis and subcutaneous tissues (Pang et al., 2004). Prominent types of subcutaneous fungal infections are sporotrichosis, mycetoma, chromoblastomycosis, and zygomycosis (Pang et al., 2004). Occasionally, these infections may be misidentified as bacterial skin infections caused by staphylococcus bacteria, thereby leading to improper treatment. This case report described the subcutaneous fungal infection which was initially misdiagnosed as the bacterial infection of the skin due to its similar clinical presentation.

CASE PRESENTATION

A 2-year-old boy made several visits to a primary healthcare clinic due to skin lesion situated beneath his right eye for three weeks. It began as a minor puncture wound, which was reported to be caused by a poke from a small iron rod (Figure 1). Later, it developed into a swollen, red, and painful lump for three weeks (Figure 2). The lump became larger and more painful during that period. Initially, he also had a fever that lasted for one week but has subsided. On his first consultation at the clinic, he was prescribed topical antibiotic ointment and syrup antibiotic. The preliminary diagnosis was pre-septal cellulitis near the right eye. Despite a week of medication, the lesion showed no signs of improvement, prompting a second round of antibiotics. Even after completing the treatment, there was no notable progress in the healing of the lesion. The patient was then referred to a dermatology clinic for further evaluation.

On physical examination, he was well and afebrile. The vital signs were also normal. There was a 3cm x 2cm lesion on the right cheek just below the right eye (Figure 2). The lesion was erythematous, warm and tender on palpation. There was no palpable lymph node.

Upon seeing this patient at the dermatology clinic, skin biopsy was performed for diagnostic confirmation. Sample was analysed for both bacterial and fungal infections. Results showed no significant bacterial growth, but fungal cultures resulted in the growth of non-sporulating hyaline mold. This confirmed the diagnosis of subcutaneous mycosis.

The treatment was commenced with a daily dose of 62.5 mg of syrup terbinafine for two weeks. Upon completing this treatment, the lesion improved but was not completely cleared (Figure 3). The patient was then prescribed 55 mg of itraconazole syrup twice a day for one week. Upon reviewing the patient two weeks later, it was observed that the lesion was resolved completely (Figure 4). Since the patient consumed itraconazole syrup, liver function test was conducted before initiation of syrup itraconazole and after completed therapy. Both results were within the normal range.

Figure 1: Minor puncture wound caused by a poke from a small iron rod.

DISCUSSION

Subcutaneous mycoses are a group of fungal infections caused by a heterogenous group of fungi that infect the skin, subcutaneous

Figure 2: Progression of skin lesion.

Figure 3: Hypertrophic scar in the right infra orbital area. A few pinpoint papules on erythematous macule on the right side between nasal bridge and cheek.

Figure 2: Hypertrophic scar in the right infra orbital area. No new papules or nodules.

tissue and, in some cases, deeper tissues and organs. The causative agents are commonly found in soil, leaves, and organic material, and are introduced by traumatic injury to the skin (La Hoz & Baddley, 2012; Warnock, 2012). The majority of these infections stem from fungi thriving as decomposers in nature. There are superficial, subcutaneous, and systemic types of fungal infections. Fungi can manifest as yeasts that reproduce through budding, or as molds with thread-like structures known as hyphae that weave together into a network called mycelium, or as dimorphic fungi capable of growing either as yeast or mold depending on the conditions.(La Hoz & Baddley, 2012).

Subcutaneous fungal infections caused by mold typically arise from the introduction of fungal spores into deeper skin layers through pre-existing open wounds or breaks in the skin barrier. (Kozel & Wickes, 2014). Mold begins its life cycle as ubiquitous spores found in soil, air, and on various surfaces. When these microscopic spores land on a suitable environment, such as human skin, they can germinate under favorable conditions like warmth, moisture, and often keratin-rich substrates like skin, hair, or nails. Following this initial germination, a period of incubation occurs, which can last anytime from days to months before any visible symptoms appear. The first noticeable sign of infection is typically

a firm, painless or slightly tender nodule on the skin, ranging in color from pink to almost purple. At this stage, as the fungus establishes itself and multiplies, germination gives rise to hyphae, thread-like filaments that penetrate the skin's outermost layer (epidermis). These hyphae then spread, either across the skin's surface or within hair follicles, solidifying the infection. As the infection progresses, the lesion becomes more prominent and undergoes visible changes in appearance. (Warnock, 2012: Cole et al., 1996: Pang et al., 2004) As the infection progresses, the initial nodule may transform into an open sore or ulcer, potentially draining clear fluid. The lesion's appearance continues to evolve in response to both fungal growth and the body's immune response. Eventually, the maturing fungus begins to produce new spores, potentially spreading the infection to other skin areas. This can manifest as an increase in the number or size of lesions. Without treatment, these nodules and ulcers can become chronic, persisting for years with a stable appearance despite the ongoing infection. (Warnock, 2012: Cole et al., 1996: Pang et al., 2004). The evolution of the skin lesion was seen in this case.

Although non-sporulating hyaline molds are frequently isolated from patients and have been recognised as agents of pulmonary disease, their clinical significance in cutaneous specimens is relatively unknown. Previous study has shown that some non-sporulating hyaline molds affect both cutaneous and subcutaneous tissue infections (Jeyaprakasam et al., 2016). Nonsporulating hyaline molds are fungi that do not readily produce spores under certain laboratory conditions and have clear or translucent (hyaline) hyphae. Without spores, it is challenging for mycologist to identify specific type of mold as spore formation is the key feature in mold identification (Silvarajoo et al., 2021).

Subcutaneous fungal infections and bacterial infections can indeed present with similar symptoms, such as erythema, warm and swelling (La Hoz & Baddley, 2012; Ally, 2011). Typically, fungi can cause infections when the immune system is compromised, or when there is a breach in the integrity of the mucocutaneous barrier as in this case. Diagnosis of fungal infections can be difficult, and this may delay the initiation of appropriate therapy. The diagnosis relies on cultures, and specific molecular techniques to differentiate between bacterial and fungal infections (Kozel & Wickes, 2014). Nevertheless, it is essential to establish the correct the diagnosis to provide a proper treatment (Dalbeni, 2023).

The choice to prescribe terbinafine syrup instead of itraconazole was initially made due to the lower side effects associated with terbinafine, which is particularly important to consider when treating a child with systemic antifungal medication (Elewski & Tavakkol, 2005). Terbinafine proved to be an effective treatment option for subcutaneous fungal infections caused by non-sporulating fungal strains (Elewski & Tavakkol, 2005). However, in this case, despite completing a two-week course of terbinafine, the skin lesion was still not completely resolved. Consequently, the treatment was changed to itraconazole due to its broader coverage for all types of fungal infections, including both yeast and mold (Elewski & Tavakkol, 2005). Since this patient received itraconazole treatment, potential side effects were closely monitored through liver function test due to the higher risk of hepatotoxicity (Elewski & Tavakkol, 2005). For this patient, liver function tests were conducted before commencing the treatment with itraconazole syrup and after completing the therapy. All test results were within normal range.

CONCLUSION

Subcutaneous infections are commonly presented by patients seeking treatment at primary healthcare clinics. The infections are typically caused by bacteria. However, in circumstances where lesion does not respond

to antimicrobial treatments, it is essential to consider other potential diagnosis, including subcutaneous fungal infections. This case report aims to emphasise the importance of considering subcutaneous fungal infection as a differential diagnosis. Considering the extensive side effects associated with systemic antifungals treatment, it is essential to initiate therapy only after the diagnosis is confirmed, rather than treating empirically relying solely on clinical suspicion.

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CONFLICT INTEREST

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CONSENT

Written consent was obtained from parents before the preparation of this case report.

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CASE REPORT

Tropical Primary Pyomyositis of The Right Calf Muscle: A Rare and Unexpected Complication of Jump Squat Exercise

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ABSTRACT

Diagnosing pyomyositis in its initial or invasive stages can pose a challenge due to its vague initial symptoms, which may mimic other conditions such as muscle strain, localized myositis, hematoma, deep vein thrombosis, cellulitis, or thrombophlebitis. A high index of suspicion for possible pyomyositis necessitates confirmation through radiographic imaging. A delayed diagnosis directly correlates with the time taken to commence treatment, thereby increasing the risk of patient morbidity and mortality. We present a case of a diabetic male who experienced bilateral calf muscle pain and right calf swelling after participating in jumping squat exercises, eventually developing right calf myositis and abscesses over a two-week period, which were initially overlooked by several general practitioners. This case underscores the crucial role of radiographic imaging in confirming the diagnosis, whether in the Emergency Department or any primary care setting. Prompt diagnosis and intervention, as demonstrated here, are imperative for minimizing the risks associated with this potentially severe disease. Knowledge of this condition and its diagnostic methods is highly advantageous for emergency physicians, primary care providers, and family physicians.

INTRODUCTION

Pyomyositis is an acute bacterial infection that

occurs within skeletal muscles and usually results in abscess formation. It is neither secondary to a contiguous infection of the soft tissue or bone nor due to penetrating trauma (Bickel J et al., 2002). Pyomyositis is also known as tropical pyomyositis or myositis tropicans since cases are frequently reported from tropical regions (Agarwal V et al., 2011).

Pyomyositis is commonly seen in immunosuppressed individuals, such as people living with human immunodeficiency virus/acquired immunodeficiency syndromes (HIV/AIDS), diabetes mellitus, leukemia, cancer or malignancy, renal failures, liver disease, and autoimmune diseases (Crum NF. 2004). Pyomyositis has been related to insults that affect skeletal muscle, such as rigorous physical exercise, trauma, injecting drug use, intramuscular injection and underlying viral or parasitic myositis (Amoozgar B et al., 2019).

We present a case of a diabetic male who participated in a jumping squat exercise, resulting in bilateral calf muscle pain. Over two weeks, he developed right calf myositis and abscesses, which were initially missed by several general practitioners. This case emphasizes the critical role of early detection in preventing the serious complications of pyomyositis such as severe sepsis necrotizing fasciitis, or the spread of infection to surrounding tissues (Chiu S et al, 2008). Prompt diagnosis and intervention, as exemplified here, are crucial for minimizing the risks associated with this potentially devastating disease.

CASE PRESENTATION

A 50-year-old Malay man presented at the Emergency Department (ED) complaining of persistent bilateral calf pain and unresolved swelling in his right calf muscle over the past two weeks. These symptoms began after he returned home from a team-building program organized by his institution, during which he actively participated in outdoor activities. He reported experiencing bilateral calf muscle pain after performing multiple jumping squats. Subsequently, he noticed a gradual increase in swelling in his right calf muscle, accompanied by tolerable pain and tenderness. He denied any history of physical injuries or insect or animal bites during these activities.

He visited a General Practitioner who diagnosed it as a soft tissue injury (hematoma and sprain/strain) and prescribed pain relief medication. He also sought treatment from a masseur, but despite these efforts, the pain and swelling persisted without improvement. Nonetheless, he managed to carry out his daily tasks with slight difficulty, particularly during movement, due to the persistent pain and swelling. He denied any history of fever, cough, shortness of breath, chest and back pain, muscle weakness, numbness, nausea and vomiting, or urinary symptoms. The patient suffered from diabetes mellitus for the past 15 years, and it was well controlled with medication.

During the general physical examination, he appeared alert, had a healthy complexion, and showed signs of good hydration. His oral temperature was 37.20 Celsius, pulse rate 84 beats per minute, respiratory rate 16 breaths per minute, and blood pressure measured at 170/90 mmHg. Cardiovascular, respiratory, and abdominal examinations showed normal findings. However, examination of the lower limb revealed bilateral calf tenderness without discoloration of the underlying skin. There was an immobile, non-fluctuant swelling over the right calf muscles, measuring 4 x 3 cm. The mass felt firm, moderately tender, slightly warm, with ill-defined margins, and normal overlying skin. There was slight edema in the right lower leg. Calf pain was elicited during both dorsiflexion and plantarflexion of the right foot. No puncture marks, scratches, injuries, or discoloration were observed on the lower extremities. No palpable right inguinal lymph nodes were detected.

The laboratory results revealed elevated

levels in the total white count, erythrocyte sedimentation rate, C-reactive protein (CRP) and random blood sugar, measuring 13.3x106/L, 54 mm/hour, 42 mg/L, and 18.2 mmol/L, respectively. However, hemoglobin, platelet counts, blood urea, creatine kinase, serum electrolytes, and urine leukocyte and nitrite were within normal ranges.

Ultrasound of the right lower limb indicated increased echogenicity in the lateral gastrocnemius muscle with a collection measuring 2.2 x 0.9 cm. Subcutaneous edema was observed at the posterior aspect of the right leg (Figure 1). The MRI revealed diffuse hyperintense signals on T2W and TIRM within the lateral gastrocnemius muscle, along with a focal collection measuring 2.1 x 1.1 x 1.4 cm (Figure 2). This collection displayed a hypointense rim on the HEMO sequence. Based on the MRI findings, myositis with intramuscular abscess formation was suspected.

Figure 1: Ultrasound image of right lateral gastrocnemius showing a hypoechoic collection

We referred him to an orthopedic surgeon for incision and drainage under general anesthesia. The diagnosis of pyomyositis in calf muscle was made. However, the source of infection was unknown. Approximately 3-5 mL of pus was drained (Figure 3), and the collected pus was sent for gram stain, culture, and sensitivity tests (C&S). We administered Intravenous antibiotic (cefuroxime 1.5 g stat

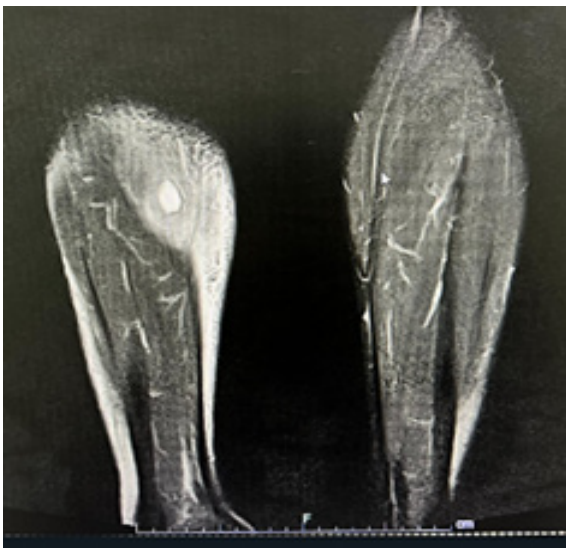

Figure 2: Sagittal view of MRI right lower extremity revealed diffuse hyperintense signal on T2W and TIRM within lateral gastrocnemius muscle. Focal collection of hyperintense signal on T2W and hypointense signal on T1W in lateral gastrocnemius muscle measuring 2.1 x 1.1 x 1.4cm. The collection demonstrated hypointense rim on HEMO sequence. Diffuse enhancement noted within the lateral gastrocnemius muscle. No enhancement of the intramuscular collection in lateral gastrocnemius muscle demonstrated. There was also hyperintense signal on T2W and TIRM in medial gastrocnemius muscle, at lateral proximal aspect. Diffuse subcutaneous thickening and edema at posterior aspect of right leg. No obvious muscle retraction or complete disruption of the muscle. Visualized lower leg vessels are patent.

dose followed by 750 mg 3 times a day) and subcutaneous insulin (Novorapid) 6 unit three times a day. Following wound dressing, the wound was packed with gauze soaked in normal saline. Pus C&S demonstrated heavy growth of Staphylococcus aureus. The organism was sensitive to cefuroxime, augmentin, unasyn, cloxacillin, and other antibiotics.

The subsequent course in the hospital was uneventful. The CRP level decreased from 42 to 18 mg/L. His diabetes medication was optimized. He was discharged with oral

cefuroxime for 2 weeks, etoricoxib, metformin, and empagliflozin. An appointment for a follow-up at the orthopedic clinic was scheduled. During his recent follow-up, two weeks after the incision and drainage procedure, he was completely well, asymptomatic, and the wound had healed satisfactorily.

Figure 3: Pus was drained from the gastrocnemius muscle

DISCUSSION

Pyomyositis is an uncommon pyogenic bacterial infection affecting the skeletal muscles, typically caused by Staphylococcus aureus. It is marked by the development of a single or multiple abscesses within the muscle tissue (Chiedozi LC, 1979). Commonly involved muscles are quadriceps, glutei, pectoralis major, serratus anterior, biceps, iliopsoas, gastrocnemius, abdominal and spinal muscles (Chauhan S et al., 2004). The incidence rate of pyomyositis cases is likely attributed to the rising numbers of immunocompromised patients including cancer patients receiving chemotherapy, individuals with rheumatologic conditions taking immunomodulatory agents, as well as those with HIV infection, diabetes mellitus, and liver disease (Maravelas R et al., 2020). In our case, the most probable pathogenesis of pyomyositis involves transient bacteremia occurring alongside muscular injury induced by overexertion during jumping squat exercises and compounded by diabetes mellitus. It is improbable for bacteremia alone, without concurrent muscle damage, to lead to myositis, given the inherent resistance of healthy muscle to infection (Ngor C et al., 2021).

Pyomyositis is categorized as primary or secondary. Primary pyomyositis denotes a purulent skeletal muscle infection arising from presumed or confirmed hematogenous infection (Elzohairy, 2018). It typically results from direct invasion originating from nearby sources of infection like spinal, gastrointestinal, or urinary tract infections. These primary infections often exhibit a subacute onset and predominantly affect extremities or muscles around the hip and pelvis (Hashemi SA, 2012). Therefore, the disease is usually diagnosed late and, for this reason, it is followed by an increased morbidity and sometimes a significant mortality rate (Shittu A, 2020). Conversely, secondary pyomyositis develops from localized penetrating trauma or the spreading of infection to adjacent muscles (Elzohairy, 2018).

The progression of pyomyositis typically unfolds in three stages. Initially, during the first stage, which is typically subacute and spans 1 to 3 weeks, local swelling with a "woody" texture, mild pain, and varying fevers occur. Termed the "invasive phase," this stage involves bacterial infiltration into the muscle, though a definitive purulent collection has yet to form (Chiedozi LC, 1979). Diagnosing pyomyositis during this phase can be challenging due to its vague initial symptoms, which may resemble other conditions such as muscle strain, localized myositis, hematoma, deep vein thrombosis, cellulitis, or thrombophlebitis (Lew KS, 2019). In the second stage, known as the "suppurative" stage, occurring between 10 to 21 days, tenderness and fevers become

more pronounced (Chiedozi LC, 1979). It is during this stage that the diagnosis of pyomyositis is typically confirmed. Notably, common findings in soft tissue infections such as local erythema and regional adenitis are usually absent in pyomyositis. Without prompt diagnosis and treatment, the third stage of pyomyositis ensues, characterized by intense local pain, fluctuance, and systemic manifestations including sepsis (Chiu S et al., 2008).

In our case, the general practitioners missed the diagnosis because our patient presented with localized calf muscle pain and swelling but lacked fever. The diagnosis of pyomyositis relies on imaging. Plain films may show soft tissue swelling, but their utility is limited. Ultrasound, computed tomography (CT), or magnetic resonance imaging (MRI) scans are more sensitive at detecting pyomyositis (Agarwal V et al., 2011 and Ali SZ et al., 2013). Luckily, our Accident and Emergency Unit is equipped with timely ultrasound and MRI capabilities, facilitating diagnosis by detecting myositis and abscess formation.

Determining the causative organism is imperative to optimizing therapy. In our case, analysis of the purulent material extracted during the incision and drainage procedure demonstrated that the strain of bacteria causing the pyomyositis was S. aureus and sensitivity tests revealed that the responsible organism was sensitive to the administered antibiotic, which is intravenous cefuroxime. This finding was expected since S. aureus is the primary culprit in most cases, causing 90% of infections in tropical regions (Narayanappa, 2021) and 60 to 70% in the United States (Christin L, 1992). Notably, few studies indicate community-acquired methicillin-resistant S. aureus (MRSA) is increasingly significant as a cause of pyomyositis (Crum NF, 2004 and Kulkarni GB et al., 2009).

The next most frequent bacteria associated with pyomyositis are streptococci of groups A, B, C, and G, along with S. pneumoniae. Other less prevalent bacterial culprits of pyomyositis encompass gram-negative bacilli, anaerobes like Clostridium spp., Bartonella spp., Mycobacterium spp. like M. tuberculosis and M. avium, and Fusobacterium necrophorum (Crum NF, 2008). The suggested length of antibiotic therapy for pyomyositis usually spans between 2 to 6 weeks, contingent upon various factors like infection severity, the specific causative agent, and the patient's treatment response. In our case, he was completely well and asymptomatic after completing 2 weeks of oral antibiotic. Prolonged treatment may be necessary for multifocal or severe cases, especially when dealing with organisms like Mycobacterium spp (Simopoulou T, 2016). Generally, prognosis is favorable with complete recovery being common; however, recurrence is rare but can happen among immunosuppressed individuals or in cases of atypical infections such as Mycobacterium or Salmonella (Radcliffe C, 2020).

CONCLUSION

This case underscores the nearly missed diagnosis of pyomyositis in the right calf muscle of a poorly controlled diabetic patient with a history of bilateral gastrocnemius injuries due to excessive jumping squat exercise. The condition was almost overlooked due to lack of experience and the absence of fever. A high index of suspicion and confirmation through radiographic imaging are crucial for making the diagnosis. Understanding this rare complication of jump squatting exercises is invaluable for emergency physicians, primary care practitioners, and family doctors.

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CONFLICT INTEREST

The authors declare that they have no conflict of interest to publish this case report or sponsorship to declare.

CONSENT

Written consent was obtained from the patient prior to the commencement of this case study.

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CASE REPORT

A Case of Disseminated Tuberculosis with Atypical Presentation in an Older Person

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ABSTRACT

Tuberculosis (TB) is an infectious disease caused by Mycobacterium tuberculosis. It is a significant health concern, with millions of new cases and deaths reported each year. Disseminated tuberculosis (dTB) is a serious condition which can affect various organs and tissues, leading to widespread symptoms and complications. The diagnosis of dTB can be challenging due to its atypical presentations. We present a case of dTB in a robust older person who presented with musculoskeletal pain, weight loss, and loss of appetite. Initially, he was treated for age-related spine disease, and pain management was provided. However, his subsequent visit raised suspicion of TB, prompting further work up. The diagnosis was revised to dTB, and anti-TB treatment was initiated. The near miss or delay in diagnosis and treatment may have played a role in dissemination of disease, increased frailty and reduction of function in this patient. Healthcare workers must maintain a high index of suspicion and remain vigilant for TB as starting early treatment will prevent dissemination in the patient, reduce risk to the public and improve outcomes.

Keywords: *Disseminated tuberculosis, Atypical presentation, Older patient*

INTRODUCTION

Tuberculosis (TB) remains a major public health concern in Malaysia, with 25 391 new cases recorded in 2022.The notification rate stands at approximately 78 cases per 100,000

individuals (Health, 2022). Disseminated tuberculosis (dTB) is defined as having two or more non-contiguous sites resulting from lymphohematogenous dissemination of Mycobacterium tuberculosis (MTB) (Ayaslioglu et al., 2009). The incidence of TB is greater in the older person due to higher rates of TB reactivation as a result of impaired T-cell mediated immune responses (Rajagopalan, 2001). Diagnosis of dTB can be challenging due to its nonspecific clinical manifestations and potential mimicry of other disorders such as malignancies and age-related diseases. It may be life-threatening if the diagnosis and treatment is delayed. Herein, we describe a case of dTB in an older individual with no significant past medical history.

CASE PRESENTATION

A formerly robust 75-year-old Chinese gentleman presented to the emergency department at Hospital Selayang, Selangor in May 2023 with a three month history of lower back pain, weight loss, and reduced appetite. Physical examination revealed a moderately built man with reduced power (3/5) over the lower limbs bilaterally with upgoing plantars. The rest of the examination was unremarkable. An X-ray of the spine demonstrated a compression fracture at vertebra T11 while blood investigations were normal. A diagnosis of cervical spondylosis myelopathy was made and he was admitted to the orthopaedic ward for further management. The pain improved but the weakness remained in the lower limbs. Nevertheless, he was discharged after three days with an appointment for magnetic resonance imaging (MRI) of the spine as an outpatient.

He attended the emergency department two-months later with worsening back pain and diarrhoea of 5 days duration. His mobility had been restricted since discharge resulting in functional impairment and deconditioning. He had become dependent and required assistance for his basic activities of daily living such as bathing, dressing and toileting. Clinical examination revealed weakness in the lower limbs as previously described. He was also noted to have episodes of hypotension and low capillary blood glucose in the ward.

Blood investigations (Table 1) revealed hyponatremia and hyperkalemia. Plasma glucose was within the normal range. In view of the biochemical abnormalities with episodes of hypotension, a morning cortisol level was sent. This subsequently came back as low confirming hypocortisolism. The chest X-ray (Figure 1) revealed cavitation over the right middle zone with opacification in the upper and lower zones of the right lung. There was also bilateral perihilar nodular calcification. MRI of the spine (Figure 2) was expedited and performed whilst an inpatient. This revealed compression fractures across multiple vertebrae with evidence of spinal stenosis. However, a bone biopsy was not performed due to patient's refusal of the procedure.

In view of these findings, screening was performed for the possibility of TB. Sputum for acid-fast bacilli (AFB) were negative. However, the sputum GeneXpert MTB/RIF test result returned as positive. Tumour markers sent for completeness were negative. He was referred to endocrinology for the adrenal insufficiency. We concluded that this is likely adrenal tuberculosis secondary to disease dissemination. A Computed tomography (CT) scan of thorax and abdomen appointment was given for further evaluation.

A diagnosis of dTB involving the lungs, adrenal glands, and spine was made based on these findings. Immediate anti-tuberculosis treatment was initiated, which included ethambutol 1200 mg daily, pyrazinamide 1500 mg daily, rifampicin 600 mg daily, and isoniazid 300 mg daily, with pyridoxine 20 mg daily for the intensive phase of 2 months, followed by rifampicin 600 mg daily and isoniazid 300 mg daily for a minimum of 7 months. Steroid supplementation was commenced for the adrenal insufficiency on

the fifth day of admission. The compression fractures were managed conservatively. He was isolated in a negative pressure room resulting in limited rehabilitation during his hospitalization. He was discharged after ten-days of hospitalization once the pain was controlled and electrolytes normalized. Mobility remained limited and he was given outpatient appointments for continuation of physiotherapy and occupational therapy.

He completed his dTB treatment in early May 2024. His functional condition has improved, and he is now able to mobilize with an assistive device. He has transferred his follow-up care for endocrinology and orthopedics from Hospital Selayang, Selangor, to Hospital Segamat, Johor, as he has returned to his hometown and is currently awaiting a CT scan of the thorax and abdomen for further evaluation post dTB treatment.

Table 1: Blood investigation results on presentation

Investigations	Result	Unit Type	Reference range
Hemoglobin	12.6	g/dl	13 - 17
White blood cell	5.7	103/uL	4 - 10
Platelet	165	103/uL	150 - 410
Sodium	121	mmol/L	136 - 146
Potassium	5.8	mmol/L	3.4 - 4.5
Urea	7.3	mmol/L	2.8 - 7.2
Creatinine	97	umol/L	64 - 104
Cortisol	98	nmol/L	138 - 635
Alpha feto protein (AFP)	1.4	ng/mL	0 - 9
CA 19-9	8.1	U/mL	0 - 35
CEA	3.2	ng/mL	0 - 5
PSA	2.9	ng/mL	0 - 4

DISCUSSION

TB is endemic in Malaysia. The World Health Organization (WHO) has ranked this country as an intermediate TB burden country. dTB presents a significant global public health challenge and is associated with marked morbidity and mortality. This condition has the potential to mimic various illnesses and with limited diagnostic tools, up to 50% of cases are undiagnosed prior to death in some case series.

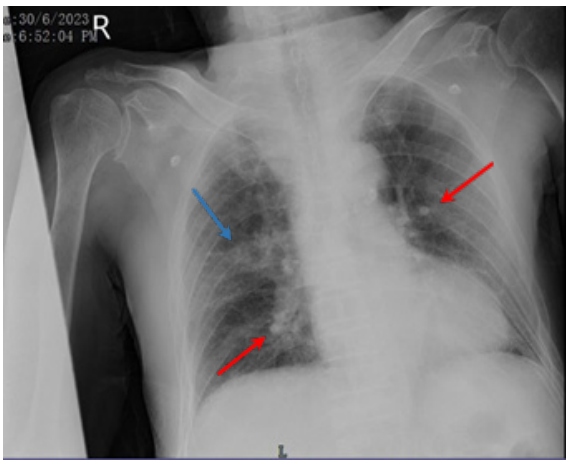

Figure 1: Chest x-ray showed opacities seen over right upper, middle and lower zones. Rounded opacities projected over bilateral perihilar and mediastinum region with some of it calcified (Red arrow). Cavitation over right middle zone (Blue arrow)

Diagnosis of dTB can be challenging due to the nonspecific clinical characteristics in older persons which may be confused with age-related illnesses. The typical TB symptoms of cough, haemoptysis, fever, drenching night sweats and weight loss may not be evident in older patients. Non specific symptoms, such as weakness, dyspnoea, anorexia and mental change, are more frequent in older patients with TB compared with younger patients (Byng-Maddick & Noursadeghi, 2016). There is limited data on dTB in older patients in the literature.

The heightened vulnerability in older persons is attributed to several factors, including immunosenescence, physiological changes associated with aging, malnutrition and comorbidities. Immunosenescene is

Figure 2: MRI whole spine showed Reduce T5, T11 and T12 vertebral body height suggestive of compression fracture (Red arrow). Spinal stenosis worst at T11 vertebral body. Bilateral T11 exiting nerve roots are not visualized likely to be compressed.

an age-related condition where there is hematopoietic stem cell dysfunction and thymus involution. Both events decrease T-cell generation resulting in decreased levels of naive T-lymphocytes accompanied by the impaired ability of T cells to achieve immunological memory. These changes favour infections such as TB in the older person (Muller et al., 2019). Although the primary cause of adrenal insufficiency is autoimmune, TB remains major cause in developing countries (Arlt & Allolio, 2003).

According to the Malaysian clinical practice guidelines, the initial diagnostic tool for MTB is smear microscopy with Ziehl-Neelsen staining (AFB staining). This has limited sensitivity. Mycobacterial culture remains the gold standard for confirmation of MTB but requires four to eight weeks to obtain an isolate and determine its susceptibility to antibiotics (Adler et al., 2005). Both methods have limitations for the early detection of MTB. A better tool which the WHO has endorsed is the Gene-Xpert MTB/RIF assay, which can detect MTB within two hours by using a nucleic acid amplification technique with a sensitivity and specificity of 97.83% and 92.59% respectively (Dye & Williams, 2008), (Shah, 2016). It has become an excellent clinical tool for early detection of smear negative TB as well as Rifampicin resistance.

Clinical diagnosis of dTB is confirmed if a patient has any of the following conditions: (1) Isolation of MTB from blood, bone marrow, liver biopsy specimen, or ≥2 non contiguous organs; (2) Isolation of MTB from 1 organ and histologic demonstration of caseating granulomatous inflammation from the bone marrow, liver biopsy specimen, or another non contiguous organ; (3) Isolation of MTB from 1 organ and radiographic finding of miliary lung lesions (Fahmi Yousef Khan, 2016). In this case, dTB was not considered during his initial presentation due to a combination of low clinical suspicion and a lack of typical symptoms. The subsequent admission raised the concern of dTB based on the persistent symptoms, confirmed hypocortisolism, radiological findings and the positive Gene-Xpert MTB/RIF assay. The delay in diagnosis and treatment may have played a role in dissemination of disease, increased frailty and reduction of function in this patient.

Disseminated tuberculosis is a life-threatening condition, with a reported mortality of up to 30%, (Khan, 2019). Early detection can significantly reduce morbidity and mortality. Further research is needed to identify the impact of dTB in the older patients for future clinical practice.

CONCLUSION

Tuberculosis is a common disease which can present atypically. Healthcare workers must maintain a high index of suspicion and remain vigilant for TB as starting early treatment will prevent dissemination in the patient, reduce

risk to the public and improve outcomes.

CONFLICT INTEREST

None

CONSENTS

The participant provided written informed consent to participate in this study. Additionally, written informed consent was obtained from the individual for the publication of any potentially identifiable images or data included in this article.

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ETHICAL ISSUES

This case report has obtained approval from the National Medical Research Register (NMRR), Ministry of Health Malaysia: NMRR ID-23-02640-AZZ

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