Effect of Using 5% Potassium Permanganate Dressing Solution on Accelerating Cellulitis Healing Process

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Abstract

Background: Cellulitis is considered as a one of the common acute skin infection which causes pain, swelling and erythema. Moreover, it may carry a socioeconomic burden. Recently, 5% potassium permanganate dressing solution has been extensively used as a trustworthy antiseptic as for many types of wounds. **Aim**: to determine the efficacy of Potassium permanganate dressing solution on accelerating cellulitis healing process. **Design**: Quasi-experimental design**. Setting:** At inpatient surgical department at Alexandria Main University Hospital. **Subjects**: a convenience sample of 40 adult cellulitis patients of both sexes. **Results:** no statistically significant difference between both groups during the 1st assessment was found. During 2nd and 3rd assessment, there were statistically significant differences in the study group over the control group in most items of cellulitis severity assessment. **Conclusion**: 5% potassium permanganate solution as a topical antiseptic dressing solution for cellulitis is viable and well tolerated, effectively hastening the cellulitis healing including decreasing the severity of pain, edema and erythema.

Key words: Potassium Permanganate Dressing Solution, Cellulitis, Treatment

Introduction:

Cellulitis is an acute inflammatory bacterial infection affecting primarily the skin and subcutaneous tissue that spreads briskly with no treatment or with improper management. An acute onset of erythema, pain, heat and swelling are the unique character. Within severe cases, blistering may present buildup of edema, lymphangitis and lymphadenopathy. Also, flu like symptoms may appear prior or post visible manifestation in the skin. The most conjoint infecting organisms were streptococcus pyogenes (27%) and Staphylococcus aureus (51%) **(Sutherland & Parent., 2017; Park et al., 2016)**.

Cellulitis can be categorized into various dissimilar types, according to where it seems. It can be surrounding the eyes, identified as periorbital cellulitis; round the eyes, nose, and cheeks, identified as facial cellulitis, breast cellulitis and peri-anal cellulitis that arising around the anal orifice **(Raj & Kudari., 2020; Bojesen et al., 2019)**.

Furthermore Park et al., 2016, informed that cellulitis is linked with several risk factors as diabetes, lymphoedema, chronic oedema, insect bites, skin trauma or ulcers. In addition, blistering disorders, bullous pemphigoid, bullous impetigo, animal bites, skin rash, venous stasis eczema, and athlete's foot (tinea pedis) were encountered. Furthermore, dry skin, pregnancy, obesity, burns, recent surgery, immunodeficiency (cancer, kidney and liver disease, peripheral vascular disease), immunosuppressive drugs, intravenous drug misuse, and alcoholism were linked with

cellulitis. Thus, cellulitis arises after failure of the skin's integrity secondary to trauma, surgery, insect bites, tinea infection, and often in patients with current skin conditions such as eczema and psoriasis **(Sutherland & Parent., 2017; Singh & Sreenivasa., 2018)**. So, the patients should be alert for their possible risk factors for prevention of further episodes.

As regards to treatment of cellulitis, antibiotic treatment is the mainstay of management, while there are varying recommendations for the choice of antibiotic agent and the length of treatment. The recommendations regarding supportive treatment are heterogeneous and include bed rest, leg elevation, intermittent pneumatic compression, corticosteroids, cycloidal vibration and compression bandaging **(Andersen et al., 2021)**. Moreover, all antibiotics have side effects include constipation, diarrhoea, nausea and possibly vomiting. Additionally, antibiotic resistances are present. So, all clinicians are urged to use antibiotics judiciously **(Mohsen, James, and Somayaji, 2020).**

In the light of this, the growth in antibiotic resistance is a forthcoming and predominantly silent threat, which would lead to an extraordinary situation with multivariable implications. While the skin is one of the furthermost common areas where antimicrobial resistance develop; the prior issues make critical is the use of non-antibiotic antimicrobial agents as topical potassium permanganate **(Lara-Esqueda et al., 2021; Babalska et al., 2021; Bassukas et al., 2016)**.

Potassium permanganate is a potent oxidizing and astringent agent, its chemical features display specific properties that make it useful in the treatment of wounds. As an oxidizer, potassium permanganate presents the capacity to disrupt the bacteria's organic materials including the cell wall, the cytoplasmic membrane, the proteins and the DNA. Also it has a role in wound healing process **(Lara-Esqueda et al., 2021)**.

According to **Abd Wahab et al., 2021**; potassium permanganate dressing has been extensively used as a consistent antiseptic. Also, **Delgado-Enciso et al., 2018** conveyed a statistically significant lessening extent of cellulitis in diabetic foot ulcer with p value < 0.01. Furthermore, **Lara-Esqueda et al., 2021** confirmed that potassium permanganate solutions aid in eradication of anaerobic microenvironment and attain worthy therapeutic effect on gas gangrene and mixed infection. Vaccum Sealing Drainage (VSD) with constant irrigation of potassium permanganate is a simple, novel and feasible alternative for severe traumatic open wounds with gas gangrene infection.

Cellulitis is a common infectious disease. It is accountable for important morbidity and mortality that may necessitate repeated hospital admissions for early diagnosis and proper treatment. Furthermore, it may carry a socioeconomic load including duration of hospitalization and great financial costs. Just, the development in patient managing, including a high index of suspicion together with a proper use of non-antibiotic antimicrobial agents, have significantly improved the short-term prognosis, decrease in the rate of recurrence, repeated hospitalizations and hence in-hospital mortality. Numerous studies had discussed cellulitis which affirmed that causative microorganisms, pathogenesis and prognosis were quite poor. All of these urge the researcher to focus on that issue especially with the augmented incidence of antibiotic resistance.

Despite the growing popularity of potassium permanganate in the management of skin and subcutaneous tissue lesions and its contributions to their healing. Limited studies on the effect of potassium permanganate on healing of cellulitis were encountered. Therefore, this study aims to determine whether the topical application of 5% potassium permanganate dressing solution could improve the efficacy of the current cellulitis treatment standard.

Significance of the study:

Problem

Despite the use of antibiotic therapy and the use of conventional dressing for cellulitis treatment, Cellulitis is still a common infectious

disease and there is increasing in antibiotic resistance.

What is already known

Potassium permanganate has powerful microbicidal activity on bacteria, fungi, viruses and protozoa. As, it stimulates the development of granulation tissue and collagen production and fast-track the process of healing for wound and diabetic foot ulcer.

What is this study add

New dressing technique for cellulitis management by using 5% potassium permanganate solution**.** It is also available, cheap, easy to use.

Aim of the study:

Determine the efficacy of Potassium permanganate dressing solution on accelerating cellulitis healing process.

1.Research hypothesis:

H1: Patients with cellulitis who receive potassium permanganate dressing will exhibit improvement in cellulitis healing process than patients who do not receive such intervention.

H0: Patients with cellulitis who receive potassium permanganate dressing will exhibit the same healing rate as patients who do not receive such intervention.

Materials and Methods

Research Design:

Quasi-experimental design was used.

Setting:

The study was carried out at inpatient surgical Department at Alexandria Main University Hospital. It includes 3 male rooms with 20 beds, 3 female rooms 21 beds.

Subjects:

To estimate the sample size, Epi info program version 10 was used based on the following parameters; population size of 100 in 12-months, coefficient of 95%, expected frequency of 50%, and acceptable error of 5%. The least sample size required was 40 patients. During the period of the study, 40 out of 52 patients who approved to contribute in the study were randomly allocated to two equal parallel groups, 20 in the study group and 20 in the control group, using a random number generator program; as illustrated in Figure1

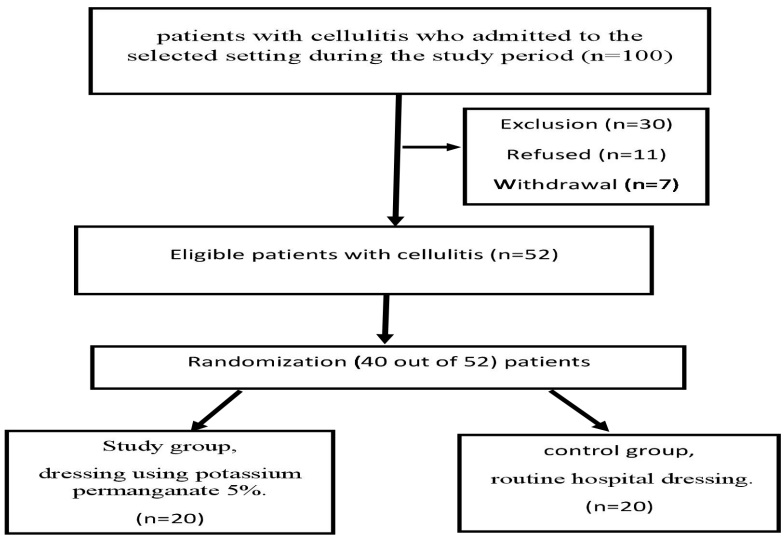

Figure-1: Flow chart of participants' recruitment process.

Subjects, inclusion criteria were: adult patients with:

- Class 1 and 2 lower limbs cellulitis with existence of clinical signs of erythema, warmth and oedema and involving limbs must have a total surface area of erythema ≥ 75cm2
- Age from 18 to 60 years.
- Both sexes.
- Willing to contribute in the study and cooperate.
- Able to communicate verbally.
- Hemodynamic stable patients.
- Absence of generalized or local gangrene.

Exclusion criteria: adult patients with:

- Immuno-compromised patients.
- Severe anemia.
- Sepsis or septicemia.
- Morbid obesity.
- Presence of necrotizing fasciitis, abscess or requiring surgical intervention,
- Identified allergy or intolerance to potassium permanganate solution.
- Burn or deep vein thrombosis.

1.1. ***Tool of the study:*** one tool used to collect data: Assessment sheet for patient with cellulitis: this tool was adapted from **(Sutherland & Parent., 2017, Singh & Sreenivasa., 2018; Raj & Kudari., 2020; Geeta et al., 2022; Harries et al., 2016)** and it entailed of two parts:

Part I: Socio demographic and clinical data: This part was prepared by the researchers after wide reviewing of related national and international literatures including items related to age, sex, educational level, occupation, smoking, chronic diseases, body mass index (BMI), previous surgeries, medication history, and cause of cellulitis.

Part II: cellulitis healing observational checklist: the researchers constructing this tool to assess healing by observations and measurement. It consists of five items related to various aspects of cellulitis assessment including**: site of cellulitis, assessment criteria for erythema or Redness**: 0= No redness,1= Redness up to 25%, 2= Redness up to 26-50%, 3= Redness up to 51-75% and 4= Redness up to 76-100%, **Assessment of Pain severity** by using rating pain level: 0= No pain, 1-3= Mild pain, 4-6= Moderate pain and 7-10= Severe pain; **Assessment of swelling:** measured in centimeter by scale or measuring tape before and after treatment and **Assessment of Warmth or Local temperature:** Local temperature will be measured by infra-red thermometer.

Inclusive Assessment Criteria: Criteria of assessment were depending on improvement in subjective and objective parameters after the treatment. The results were classified as, complete relief -- 75% and above, moderate relief -- 50% to 74% improvement, mild relief -- 25 to 49% improvement and no relief -- Below 24% improvement.

Content validity of the tool was established by 7 experts in the field of medical surgical nursing, 2 experts in surgery specialists. Minor modifications given by the experts were incorporated in the demographic variables. The tool reliability was assured by inter-rater method the association between the two rater ratings of percentage was estimated using Pearson's correlation. This association was high, r 1 = 0.92 and the mean intra-rater reliability co-efficient was r1 =0.985.

Data collection

A pilot study was carried out before starting the data collection. It was applied on 4 patients from the study settings to check and ensure the clarity, feasibility, applicability of the developed tool and to identify the difficulties that may be faced during data collection. Subjects who shared in the pilot study were excluded from the main study sample.

Data collection started with the control group who followed the routine daily hospital skin care and dressing. The study group dressing was done using potassium permanganate solution. The concentration of the potassium permanganate solution was chosen as 5% as this is the commercially available pharmacologic concentration for use as a topical antiseptic. ***First assessment*** of cellulitis severity score were done for control and study group before initiation of treatment as a base line data.

Potassium permanganate (KMnO4) dilution 1:10000 wet wrap at different areas of the same or different leg for 15 minutes twice a day; one every 12 hours for 7 days.

Standardized similar 2 pieces of gauze dressing equal to size of 3-inch length x 6-inch width at each intervention site. Similar plasters were used and marked with a waterproof skin marker. All measurements were completed with standardized similar flexible plastic measuring tape.

Cellulitis severity score was used as using a numerical value based on the following parameters; none =0, mild =1, moderate= 2, and severe =3; based on erythema, warmth, tenderness, edema, ulceration, drainage and fluctuance at the affected area (**Ab Wahab et al., 2021**). ***Second assessment*** for erythema and edema performed by a single investigator, measured as percentage of reduction of total surface area erythema; and edema reduction by decreasing in limb circumference was done after 3 days from first assessment. ***Third assessment*** was done after 7 days from first assessment. A period of 6 months (from October 2021 to April 2022) were taken for data collection.

Ethical considerations

Ethical approval to perform the study was obtained from the Research Ethical Committee of Faculty of Nursing, Mansoura University. Official permission for conducting the study was obtained from the director of the previously mentioned setting. Every patient was informed that he has free decision to voluntarily contribute in the study or withdraw at any time. In addition to the anonymity and confidentiality of their responses and privacy would assert. After their agreement, written informed consent was obtained. Privacy was also maintained during the implementation of the study.

Statistical analysis of the data

Data analysis was utilized using the Statistical Package for Social Sciences (SPSS) version 23 for. Descriptive statistics including numbers and percentages were used to describe characteristics and clinical data. Kolmogorov-Smirnov test was used to check the normality of study variables, and it showed that they were normally distributed. In Analytical statistics, Chi-square and Fisher Exact tests were used to compare severity scores for the two groups. All the statistical analyses were considered significant at $P < 0.05$.

Results:

Table (II): Shows the frequency distribution of the study and control groups according to their history and clinical data for patients with cellulitis.

In relation to having cellulitis before 75.0% of the study group didn't have cellulitis before while, 60.0% of the control group had cellulitis before. Regarding presence of chronic disease 60.0% and 50.0% of the study and control group respectively have chronic disease. 41.0% and 40.0% of the study and control group respectively have hypertension. Regarding body mass index 50.0% and 40.0% of the study and control group respectively were obese. 65.0% of the study group didn't have previous surgery and 57.1% of them had tonsillectomy while, 60.0% of the control group had previous surgery and 41.7% of them had Appendectomy. Finally, half (50%) of patients that has chronic diseases were had hypertension. There was no statistically significant difference between patients in the study and control groups regarding history and clinical data.

Table (III): Shows the frequency distribution of the study and control groups according to starting, manifestations and etiology of cellulitis.

Regarding onset of cellulitis two fifths (40.0%) of the study group cellulitis started since

1-<3 days. The same percentage in the same group cellulitis started since >6 days. Whilst, less than half (45.0%) of the control group cellulitis started since 3-<6 days. Half (50.0%) of the study group complained of redness, pain and swelling and less than half (45.0%) of the control group complained of redness and tenderness. As for etiology of cellulitis 30.0% of the study group cellulitis caused by skin conditions as, eczema, athlete's foot, or psoriasis, whereas the same percentage in the control group cellulitis caused by grazes. 55.0% of the study group and 65.0% of the control group had cellulitis in the right leg. There was no statistically significant difference between patients in the study and control groups in relation to starting, manifestations and etiology of cellulitis.

Table (IV): Reveals frequency distribution and significance of differences of cellulitis assessment criteria among the study and control groups.

In relation to assessment criteria for erythema or redness during 1st assessment, all (100.0%) of the study group and 95.0% of the control group had redness up to 76-100%. There was no statistical significant difference between both groups. In relation to assessment criteria for erythema or redness during 2nd assessment half (50.0%) of the study group had redness up to 26-50 % whereas, the same percentage in the control group had redness up to 51-75%. during 3rd assessment 40.0% of the study group had no redness, whilst the same percentage in the control group had redness up to 26-50 %. There was a statistical significant difference between both groups in favor of the study group during the 2nd and 3rd assessment (0.091* and 0.006*) respectively.

Regarding **pain severity** during 1st assessment, half (50.0%) of the study group had moderate pain compared with 65.0% of the control group had severe pain; there was no statistical significant difference between both groups. As for **pain severity** during 2nd assessment 80.0% of the study group had mild pain, whilst 55.0% of the control group had moderate pain. In relation to **pain severity** during 3rd assessment the majority (80.0%) of the study group had no pain, whereas more than three fifths (65.0%) of the control group had mild pain. There was a statistical significant difference between both groups in the study group over the control group during the 2nd and 3rd assessment (0.028*and 0.000*) respectively.

As regard **assessment of swelling** during 1st assessment, more than half (55.0%) of the study group and 65.0% of the control group limb swelling was (>5 cm and 3-5cm) respectively. As for **assessment of swelling** during 2nd assessment 35.0% of the study group compared with 55.0% of the control group limb swelling was (3-5cm); there was no statistical significant difference between both groups during the 1st and 2nd assessment. Regarding **assessment of swelling** during 3rd assessment 35.0% of the study group compared with 5.0% of the control group limb swelling was (< 1cm). There was a statistical significant difference between both groups in the study group over the control group during the 3rd assessment (0.045*).

In relation to the **temperature difference between the affected limb and unaffected limb** during 1st assessment, the same percentage (40.0%) in both groups temperature difference was (2-4°C). Regarding the **temperature difference between the affected limb and unaffected limb** during 2nd assessment, 60.0% of the study group temperature difference was (<1°C) whereas,45.0% of the control group temperature difference was (1-<2°C); there was no statistical significant difference between both groups during the 1st and 2nd assessment. As regard the **temperature difference between the affected limb and unaffected limb** during 3rd assessment, 90.0% of the study group compared with 60.0% of the control group temperature difference was (<1°C). There was a statistical significant difference between both groups in the study group over the control group during the 3rd assessment (0.028*).

Table (V): shows the frequency distribution of the study and control groups according to overall assessment criteria of patients with cellulitis. In the 1st assessment 50.0% and 65.0% of the study and control group respectively had mild relief. There was no statistically significant difference between both groups. During 2nd assessment less than three quarters (70.0%) of the study group had complete relief whereas, 65.0% of the control group had moderate relief. There was statistically significant difference in the study group over the control group (P=0.027*).

Table (I): The Frequency Distribution of the Study and Control Groups according to their Socio-Demographic Characteristics for Patients with Cellulitis.

Socio-demographic characteristics	Groups				Test of Significance
	Study (N=20)		Control (N=20)		
	No.	%	No.	%	
Age (years)					
18-30	1	5.0	0	0.0	X^2=1.641 MC = 0.507
>30-50	9	45.0	7	35.0	
>50-65	10	50.0	13	65.0	
Gender					
Male	14	70.0	12	60.0	X^2= 0.440 P=0.507
Female	6	30.0	8	40.0	
Level of education					
Illiterate	5	25.0	3	15.0	X^2= 2.333 MC = 0.787
Read & write	5	25.0	7	35.0	
Basic education	5	25.0	3	15.0	
Secondary education	4	20.0	4	20.0	
University or higher	1	5.0	3	15.0	
Occupation					
Housewife	4	20.0	7	35.0	X^2=1.240 P= 0.734
Manual work	10	50.0	8	40.0	
Official	3	15.0	3	15.0	
Not work	3	15.0	2	10	
Marital status					
Single	2	10.0	1	5.0	X^2 = 1.067 MC= 0.737
Married	12	60.0	15	75.0	
Divorced	3	15.0	2	10.0	
Widowed	3	15.0	2	10.0	
Smoking					X^2=0.404 P=0.525
Yes	12	60.0	10	50.0	
No	8	40.0	10	50.0	

- χ^2: Chi-Square test - MC: Monte Carlo test - *level of significance = ≤0.05

Table (II): The Frequency Distribution of The Study and Control Groups According to Their History and Clinical Data for Patients with Cellulitis:

History and Clinical Data Items	Groups				Test of Significance
	Study (n=20)		Control (n=20)		
	No.	%	No.	%	
Having cellulitis before					X^2= 1.026 P = 0.311
Yes	5	25.0	12	60.0	
No	15	75.0	8	40.0	
Presence of chronic disease					X^2= 4.800 P= 0.065
Yes	12	60.0	10	50.0	
No	8	40.0	10	50.0	
Type of chronic disease	N =12		N=10		X^2=2.667 MC=0.943
Hypertension	5	41.7	4	40.0	
Diabetes	4	33.4	4	40.0	
Venous stasis	1	8.3	0	0.0	
Cardiac disease	1	8.3	0	0.0	
Hypertension and cardiac disease	1	8.3	2	20.0	
Body Mass Index					X^2=1.139 MC=0.769
Underweight	1	5.0	2	10.0	
Normal weight	2	10.0	1	5.0	
Overweight	7	35.0	9	45.0	
Obese	10	50.0	8	40.0	
Previous surgeries					X^2=2.506 P=0.768
Yes	7	35.0	12	60.0	
No	13	65.0	8	40.0	
Type of surgery	N =7		N =12		X^2=2.055 MC=0.469
cholecystectomy	1	14.3	4	33.3	
Appendectomy	2	28.6	5	41.7	
Tonsillectomy	4	57.1	3	25.0	
Medication history	N =12		N =10		X^2=0.917 MC=1.000
Antihypertensive	6	50.0	5	50.0	
Diabetic medications	4	33.3	4	40.0	
Coronary vasodilators	1	8.3	1	10.0	
Anticoagulant	1	8.3	0	0.0	

- χ^2: Chi-Square test - MC: Monte Carlo test - *level of significance = ≤0.05

Table (III): The Frequency Distribution of the Study and Control Groups according to Starting, Manifestations, Etiology and site of Cellulitis.

Cellulitis Assessment Items	Groups				Test of Significance
	Study (n=20)		Control (n=20)		
	No.	%	No.	%	
Onset of cellulitis					X^2=2.901 P=0.234
1-<3 days	8	40.0	6	30.0	
3-<6 days	4	20.0	9	45.0	
>6 days	8	40.0	5	25.0	
How did it start/how do you feel?					X^2=4.571 P=0.102
Redness and tenderness	4	20.0	9	45.0	
Redness and pain	6	30.0	7	35.0	
Redness, pain and swelling	10	50.0	4	20.0	
Etiology of cellulitis					X^2=3.143 P=0.791
Ulcers	2	10.0	3	15.0	
Burns	0	0.0	1	5.0	
Bites	1	5.0	0	0.0	
Grazes	4	20.0	6	30.0	
Trauma	3	15.0	3	15.0	
Cuts	4	20.0	3	15.0	
Skin conditions as, eczema, athlete's foot, or psoriasis.	6	30	4	20.0	
Site of cellulitis					X^2=0.417 P=0.519
Left leg	9	45	7	35	
Right leg	11	55	13	65	

χ^2: Chi-Square test - *level of significance = ≤0.05

Table (IV): Frequency Distribution and Significance of Differences of Cellulitis **Assessment criteria among the Study and Control Groups.**

	Study group (n20)						Control group (n20)						Significance level		
	1st assessment		2nd assessment		3rd assessment		1st assessment		2nd assessment		3rd assessment				
	No.	%	No.	%	No.	%	No	%	No	%	No	%			
Assessment criteria for erythema or Redness:															
No redness	0	0.0	0	0.0	8	40.0	0	0.0	0	0.0	1	5.0	χ^2=	χ^2=	χ^2=
Redness up to 25 %	0	0.0	0	0.0	7	35.0	0	0.0	0	0.0	5	25.0	1.412	4.794	12.470
Redness up to 26-50 %	0	0.0	10	50.0	5	25.0	0	0.0	4	20.0	8	40.0	P1=	P2=	P3=
Redness up to 51-75%	0	0.0	8	40.0	0	0.0	1	5.0	10	50.0	0	0.0	0.235	0.091*	0.006*
Redness up to 76-100%	20	100.0	2	10.0	0	0.0	19	95.0	6	30.0	0	0.0			
pain severity assessment															
0=No pain	0	0.0	1	5.0	16	**80.0**	0	0.0	1	5.0	3	15.0	χ^2=	χ^2=	χ^2=
1-3=Mild pain	1	5.0	16	**80.0**	4	20.0	0	0.0	7	35.0	13	**65.0**	2.257	9.093	17.659
4-6=Moderate pain	10	**50.0**	3	15.0	0	0.0	7	35.0	11	**55.0**	4	20.0	P1=	P2=	P3=
7-10=Severe pain	9	45.0	0	0.0	0	0.0	13	**65.0**	1	5.0	0	0.0	0.324	0.028*	0.000*
Assessment of swelling (how many centimeters the affected limb circumference increase from unaffected limb circumference?)															
< 1cm	0	0.0	2	10.0	7	**35.0**	0	0.0	1	5.0	1	**5.0**	χ^2=	χ^2=	χ^2=
1-3 cm	0	0.0	7	35.0	11	55.0	0	0.0	6	30.0	16	80.0	1.616	1.966	6.195
3-5cm	9	45.0	7	**35.0**	2	10.0	13	**65.0**	11	**55.0**	3	15.0	P1=	P2=	P3=
>5 cm	11	**55.0**	4	20.0	0	0.0	7	35.0	2	10.0	0	0.0	0.204	0.580	0.045*
Temperature difference between the affected limb and unaffected limb															
<1°C	4	20.0	12	**60.0**	18	**90.0**	5	25.0	8	40.0	12	**60.0**	χ^2=	χ^2=	χ^2=
1-<2°C	8	40.0	8	40.0	2	10.0	7	35.0	9	**45.0**	8	40.0	0.178	3.859P2=	4.800
2-4°C	8	**40.0**	0	0.0	0	0.0	8	**40.0**	3	15.0	0	0.0	P1=	0.153	P3=
													0.915		0.028*

χ^2: Chi-Square test - MC: Monte Carlo test - *level of significance = ≤0.05
1st assessment: at first contact, 2nd assessment: after 3days & 3rd assessment: after 7days -P1: significance between study and control group in 1st assessment, P2: significance between study and control group in 2nd assessment, P3: significance between study and control group in 3rd assessment

Table (V): The Frequency Distribution of the Study and Control Groups according to overall Assessment Criteria of patients with Cellulitis.

overall assessment Criteria	Study group (n=20)		Control group (n=20)		Significance level
1st assessment					
Complete relief	0	0.0	0	0.0	χ^2=0.921
Moderate relief	10	50.0	7	35.0	P=0.337
Mild relief	10	50.0	13	65.0	
No relief	0	0.0	0	0.0	
2nd assessment					
Complete relief	14	70.0	7	35.0	χ^2=4.912
Moderate relief	6	30.0	13	65.0	P=0.027*
Mild relief	0	0.0	0	0.0	
No relief	0	0.0	0	0.0	

χ^2: Chi-Square test - MC: Monte Carlo test - *level of significance = ≤0.05
1st assessment: after 3days & 2nd assessment: after 7days

Discussion

Cellulitis is considered as a one of the common acute skin infection taking place anywhere on the body, which resulting in pain, swelling and erythema. Cellulitis was found among a considerable number of patients in the study setting. Within the present study, half of the study group and the highest percentage of the control group were between fifty to less than sixty-five years. This is may be related to soft tissue and skin infections are frequent in this age group, they are sensitive and their co-morbidities led to get the cellulitis prognosis worse. They have numerous associated diseases such as cardiac diseases, diabetes, vascular diseases and obesity that intensify the risk for mortality from cellulitis **(Mzabi.; et al.; 2017)**.

The highest percentage of the current study sample was males and there was with no statistically significant differences regarding all socio-demographic characteristics between patients in the study and control groups. This result goes in the same line with **Quirke et al., 2017, Vom Steeg and Klein 2016 and Klein and Flanagan 2016** who found that males were 30% more likely to experience cellulitis than females. Researchers suggested that increased male predominance may be due to behavioral and biological factors with less-efficient antigen presentation, in addition to lower phagocytic activity and lower antibody production. **Vom Steeg and Klein (2016).** Also, **Ioannis et al., 2016** who reported that no statistically significant difference in relation to gender. This results were contradicted by **Ebob-Anya et al., 2019** revealed that the frequency of cellulitis was higher in female than male.

Kaspersen et al., 2015, Chang et al., 2014 and Harpsoe et al., 2016 reported that increased BMI categories were concomitant with an increased possibility of cellulitis. These results go in the same line with the result of the current study where approximately half of the study and control group were obese. Therefore, obesity increased the risk of cellulitis due to liability for obese patients to have dry skin and weakened skin barrier repair, and impaired lymphatic flow subsequent an inflammatory state **(Quirke et al., 2017)**.

The results of the present study clarified that more than half of the study and half of control group have chronic disease, mainly had hypertension followed by diabetes mellitus. This is may be attributed to diabetes increase risk for cellulitis as it cause high blood sugar and thus negatively affects immune system function and permitting bacteria and other infectious microorganisms to thrive. Similarly, **Solomon et al., 2021** informed that hypertension and hyperlipidemia were a risk factor for the relapse of cellulitis in Japanese patients. It is agreed with **Norimatsu and Ohno, 2021** revealed that hypertension is independently a risk factor for cellulitis. This contradicted by **Quirke et al., 2017** who found that no association between diabetes as a risk factor and occurrence of cellulitis.

The results of the present study presented that cellulitis accompanied by erythema, pain, swelling and increase temperature of the affected limb. This is may be attributed to neutrophil and cytokine enlisted to the affected area after bacterial invasion to the skin; leading to an epidermal reaction. This response comprises the construction of antimicrobial peptides and keratinocyte proliferation which produce the characteristic exam findings in cellulitis **(Brandon and Kristen 2021).** These results supported by **Cranendonk, Lavrijsen and Wiersinga 2017** who clarified that cellulitis may associated with fever and other local and systemic features. Local features as pain, edema and erythema requiring extensive nursing care in a form of dressing. Recently, a great concern was applied for selection of the most appropriate antiseptic solution to relieve cellulitis manifestations **(Thomas, and Bronze, 2022).**

Additional evidence established in our study was the greater difference and there was a statistical significant difference between the study and the control group during the 2nd and 3rd assessment in relation to erythema or redness assessment, pain severity, swelling and temperature difference between the affected limb and unaffected limb. This may be contributed to potassium permanganate solution is a resilient oxidizing agent that affects the cell walls of pathogenic organisms, altering their DNA structure and applying potent

microbicidal activity on bacteria, fungi, viruses and protozoa. It turns as an astringent and has a strongly alkaline pH, generating instant oxidation. Moreover, it stimulates the construction of granulation tissue and collagen synthesis, which are necessary for the healing process. Likewise, it has been described to be an effective management for certain forms of wounds (Varinder., **2022).**

Similarly several studies including **Brindle et al., 2017** indicate reduction of edema, wound size when compared to povidone iodine treated group. When comparing potassium permanganate with other wound solution as in **Abd Wahab., 2017** study results contradicted our study results and showed that there was statistically significant enhancement of erythema with super oxidized hydrogel and solution dressing compared to potassium permanganate dressing.

The results of the present study revealed that the overall assessment criteria of cellulitis had noteworthy improvement in the study group over the control after 7 days potassium permanganate dressing solution. In line with this finding **Delgado-Enciso et al., 2018** who found that topical application of 5% potassium permanganate solution, in addition to the standard treatment and cleansing regimen enhanced the healing process of chronic diabetic foot ulcers compared with usual treatment alone. This progress showed in a form of ≥ 50% reduction in ulcer size was observed in 86% of patients following 21 days of potassium permanganate treatment, compared with 40% of patients receiving standard treatment.

In conclusion, the present study established that 5% potassium permanganate solution as a topical antiseptic solution for cellulitis is well tolerated and viable, effectively accelerating the healing process, in addition to decreasing the severity of pain, edema and erythema. So, these data backing the use of 5% potassium permanganate as a topical substitute to conventional antibiotics and antiseptic agents.

Limitation of the study

In spite of this study add important results to the literature. This study needs to be repeated in a large sample size to provide more generalizable results.

Conclusion and Recommendation:

The result of the current study confirmed that 5% potassium permanganate solution as a topical antiseptic solution for cellulitis is well tolerated and viable, excellently hastening the healing process, in addition to decreasing the severity of pain, edema and erythema. So, these data backing the use of 5% potassium permanganate as a topical alternative to conventional antibiotics and antiseptic agents. To improve cellulitis healing process, decrease erythema, decrease pain severity and temperature; 5% potassium permanganate solution must be used as a topical antiseptic solution in cellulitis management protocol.

Declaration of Competing Interest

The researchers declare that they have no identified competing financial interests or personal relations that could have appeared to impact the work informed in this paper.

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References:

Ab Wahab, S. (2017). The efficacy of super-oxidised hydrogel and solution compared to potassium permanganate dressing for the management of cellulitis/Dr. Sabrina Ab Wahab (Doctoral dissertation, Universiti Teknologi MARA).

Ab Wahab, S., Taib, T., & Ridzwan, R. (2021). The Efficacy of Super-oxidised Hydrogel and Solution Compared to Potassium Permanganate Dressing for the Management of Cellulitis.

Andersen, C. A., McLeod, K., & Steffan, R. (2021). Diagnosis and treatment of the invasive extension of bacteria (cellulitis) from chronic wounds utilising point-of-care fluorescence imaging. International Wound Journal.

Babalska, Z. Ł., Korbecka-Paczkowska, M., & Karpiński, T. M. (2021). Wound Antiseptics and European Guidelines for Antiseptic Application in Wound Treatment. Pharmaceuticals, 14(12), 1253.

Bassukas, I. D., Chaniotakis, I., & Gaitanis, G. (2016). Daptomycin-Based 3 Week Treatment Scheme for the First Cellulitis Episode: Low Recurrence Rate Indicative of Decreased Recurrence Propensity? Dermatology and therapy, 6(1), 77-80.

Bojesen, S., Midttun, M., & Wiese, L. (2019). Compression bandaging does not compromise peripheral microcirculation in patients with cellulitis of the lower leg. European Journal of Dermatology, 29(4), 396-400.

Brandon D. and Kristen L. 2021. Cellulitis. Ntional library of Book, Medical University of South Carolina available athttps://www.ncbi.nlm.nih.gov/books/NBK549770/ Retrieved on August 25, 2022.

Brindle, R., Williams, O. M., Davies, P., Harris, T., Jarman, H., Hay, A. D., & Featherstone, P. (2017). Adjunctive clindamycin for cellulitis: a clinical trial comparing flucloxacillin with or without clindamycin for the treatment of limb cellulitis. BMJ open, 7(3), e013260.

Chang, Y., Kim, B. K., Yun, K. E., Cho, J., Zhang, Y., Rampal, S., ... & Ryu, S. (2014). Metabolically-healthy obesity and coronary artery calcification. Journal of the American College of Cardiology, 63(24), 2679-2686.

Cranendonk, A., Lavrijsen, J., and Prins W. (2017). Cellulitis: current insights into pathophysiology and clinical management. The Netherlands Journal of Medicine; 75(9): 366-78.

Delgado-Enciso, I., Madrigal-Perez, V. M., Lara-Esqueda, A., Diaz-Sanchez, M. G., Guzman-Esquivel, J., Rosas-Vizcaino, L. E., ... & Soriano Hernández, A. D. (2018). Topical 5% potassium permanganate solution accelerates the healing process in chronic diabetic foot ulcers. Biomedical reports, 8(2), 156-159.

Ebob-Anya, B. A., Bassah, N., & Palle, J. N. (2019). Management of cellulitis and the role of the nurse: a 5-year retrospective multicentre study in Fako, Cameroon. BMC research notes, 12(1), 1-6.

Geeta, J., & Yogesh, B. (2022). Effectiveness of Panchavalkala Pralepa and Jalaukavacharana in Reducing Duration for Regression of Vranashopha wsr to Cellulitis: A Randomized Controlled Trial. International Journal of Ayurveda and Pharma Research, 21-27.

Harpsøe, M. C., Nielsen, N. M., Friis-Møller, N., Andersson, M., Wohlfahrt, J., Linneberg, A., ... & Jess, T. (2016). Body mass index and risk of infections among women in the Danish National Birth Cohort. American journal of epidemiology, 183(11), 1008-1017.

Harries, R. L., Bosanquet, D. C., & Harding, K. G. (2016). Wound bed preparation: TIME for an update. International Wound Journal, 13(S3), 8-14.

Kaspersen, K. A., Pedersen, O. B., Petersen, M. S., Hjalgrim, H., Rostgaard, K., Møller, B. K., ... & Erikstrup, C. (2015). Obesity and risk of infection: results from the Danish Blood Donor Study. Epidemiology, 26(4), 580-589.

Klein, S. L., & Flanagan, K. L. (2016). Sex differences in immune responses. Nature Reviews Immunology, 16(10), 626-638.

Lara-Esqueda, A., Delgado-Enciso, I., Lara-Basulto, A. D., & Balayan, M. (2021). Potassium Permanganate, the Vikut® Formula, an Innovation using non-antibiotic

Antimicrobial Agents to Treat both Chronic and Non-chronic Wounds: A Clinical Approach with Scientific Evidence. Frontiers in Anti-Infective Agents: Volume 5, 5, 76.

Mohsen S., James A., and Somayaji R. (2020). Update on the adverse effects of antimicrobial therapies in community practice. Canada Family Physician Journal; 66(9): 651–659.

Mzabi A., Marrakchi W., Alaya Z., Fredj F., Rezgui A., Bouajina E., and Kechrid C. 2017. Cellulitis in aged persons: a neglected infection in the literature. Pan African Medical Journal; 27: 160.

Norimatsu Y, Ohno Y. Predictors for readmission due to cellulitis among Japanese patients. J Dermatol. 2021;48:681–684.

Park S., Yang E., Kim D., Jeong H., and Joo Sim Y. 2016. Prevalence and Epidemiological Factors Involved in Cellulitis in Korean Patients With Lymphedema. Annual Rehabilitation Medicine Journal. 2016 Apr; 40(2): 326–333.

Quirke, M., Ayoub, F., McCabe, A., Boland, F., Smith, B., O'Sullivan, R., & Wakai, A. (2017). Risk factors for nonpurulent leg cellulitis: a systematic review and meta-analysis. British Journal of Dermatology, 177(2), 382-394.

Raj, A., & Kudari, K. (2020). A Study on Clinical Profile and Prescribing Patterns for Cellulitis in Patients with Foot Ulcer and Its Prevalence in Tertiary Care Hospital. International Journal of Pharmacy &Pharmaceutical Research, Vol.:19, Issue:3

Singh, R., & Sreenivasa, P. (2018). Comparison between dressing of cellulitis with normal saline and Magnesium sulphate. International Surgery Journal, 5(4), 1255-1258.

Solomon, M., Greenbaum, H., Shemer, A., Barzilai, A., & Baum, S. (2021). Toe web infection: epidemiology and risk factors in a large cohort study. Dermatology, 237(6), 902-906.

Sutherland, M., & Parent, A. (2017). Cellulitis assessment, diagnosis and management. Dermatol Nurs, 16(4), 24-28.

Thomas, E., and Bronze M. (2022). Cellulitis Treatment & Management. Aaivlable at: **https://emedicine.medscape.com/article/214222-treatment**. Retrieved on August 25, 2022

Varinder R. (2022). Using potassium permanganate for skin conditions or wound care. Regional Medicines Information Manager, London Medicines Information Service. Available at: https://www.sps.nhs.uk/articles/using-potassium-permanganate-for-skin-conditions-or-wound-care· Retrieved on August 2022.

vom Steeg, L. G., & Klein, S. L. (2016). SeX matters in infectious disease pathogenesis. PLoS pathogens, 12(2), e1005374.