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ORIGINAL ARTICLE

A Randomized Controlled Study Comparing Incision and Drainage with Deroofing Versus Saucerization for the Treatment of Carbuncle

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ABSTRACT

Introduction: Saucerization is a common treatment for carbuncle in Malaysia but is associated with excessive bleeding and prolonged healing. Incisional and drainage (I&D) is recommended internationally, however it is not widely practiced locally partly due to lesion severity at presentation. We compared I&D with deroofing against saucerization to treat carbuncle **Methods:** We prospectively analyzed 59 patients in a single center for two years duration. All analysis was done based on intention to treat. Forty-four patients were eligible and randomized to I&D with deroofing arm (n=21) or saucerization arm (n=23). Continuous variables were analyzed using T-test for independent sample, while where distributions were skewed and logarithmic transformation did not increase normality, Mann Whitney test was applied. Differences in categorical variables were compared using Chi square test **Results:** I&D with deroofing was associated with shorter healing time (median 28 days vs 72 days, p=0.003) and less days requiring dressing change (median 28 days vs 77.5 days, p=0.002). Saucerization was observed to have higher complications (17.4%; 3 patients required de-sloughing under local and general anesthesia, 1 required blood transfusion), while I&D with deroofing was observed to have less complications (14.3%; 3 patients required further de-sloughing under local anesthesia) with shorter operating times although these were not statistically significant. *Staphylococcus aureus* was the commonest organism grown from swab cultures from both arms **Conclusion:** I&D with deroofing should be the treatment of choice in carbuncle due to significant improvement in healing time and less days required for dressing change. Future studies on cost effectiveness and effects of age, diabetes, incisional approach and lesion size on wound healing and sepsis resolution will provide a better insight on the holistic management of carbuncle.

INTRODUCTION

A carbuncle is an acute soft tissue infection involving a group of infected hair follicles (furunculosis) that progress into abscess formation. It is common in diabetics and is usually caused by *Staphylococcus aureus*.

A group of carbuncles is called carbunculosis. The standard treatment of carbuncle is early administration of antibiotics and surgery. Internationally, incision and drainage (I&D) is the recommended surgical approach for carbuncle. Sometimes, wide excision is required in extensive lesions [1]. In Malaysia, saucerization is the common surgical practice, involving excision of necrotic area and the surrounding cellulitic tissue in its entirety. The size of excision is considered adequate when the base margin is completely healthy and uninflamed [2]. The saucer-like wound is allowed to heal by secondary intention with regular dressing. Although saucerization is effective via complete removal of the source of sepsis without the need of antibiotics, it is a radical procedure that is associated with intraoperative blood loss, extensive wound size that may later require skin coverage with grafts or myocutaneous flap [3]. Healing by secondary intention usually results in unsightly scars and contractures.

The origin of saucerization as the treatment of carbuncle is poorly described and the specific techniques of saucerization itself are not readily illustrated in modern literatures. Soft tissue saucerization is sometimes performed as part of excisional procedure for atypical skin lesions to achieve clear margin. Saucerization is also more frequently described as the surgical treatment of osteomyelitis. In 1869, an incisional technique to treat carbuncle which bore similar resemblance to saucerization was described [4]. The "crucial" incision was made from border to border, and the excised margin outspread beyond the edges of the carbuncle into the adjacent healthy tissues. A radical excision technique that extended into normal tissue margin, which was similar to saucerization was also described in 1933 [5]. These techniques were clearly a separate procedure from a simple I&D. In the time where antibiotics were not widely available, particularly pre-1940's, radical excision was the preferred treatment choice. I&D was not considered as an adequate therapy as the residual tissues may still contain infection, and no concomitant anti-microbial therapy was available to be administered. However, even then, the practice of wide excision was deemed contentious. Paget in his daily practice found that there was no difference in sepsis resolution with wide excision versus I&D and was concerned with the consequent pain and prolonged healing time [4]. I&D was only favored in patients who were anemic and malnourished; fearing the significant loss of blood might contribute to further complications including mortality. A recent case series suggested shorter wound healing time in carbuncle treated with I&D with deroofing compared to saucerization, with no difference in sepsis resolution between the two techniques [2].

There were six publications in the last 20 years on the treatment of carbuncle, where only one was published in the English language. After 1940's, antibiotics expanded their role as the frontline treatment for soft tissue infections including carbuncle. Perhaps due to its common and benign course with a relatively straightforward treatment, carbuncle is unpopular and under-researched.

In Malaysia, the more radical approach towards carbuncle is adapted due to the advanced presentation of disease at diagnosis. Although never been formally studied, this is likely to reflect poor glycemic control amongst diabetic population and perceived lack of patient's awareness to present at an earlier stage.

Deroofing is a variant of I&D procedure where the "roof" of an abscess is opened and surrounding unhealthy tissues are removed, leaving a hole overlying a deep collection. We are aware that a simple I&D procedure might not be sufficient for most of advanced carbuncle cases presented to our department, therefore we performed I&D procedure with deroofing as a treatment option for maximal tissue conservation without compromising the extent of excision.

To the best of our knowledge, no studies have evaluated the best surgical approach for carbuncle in Malaysia. Therefore, we aimed to study this controversial issue on whether such a radical procedure is necessary for a benign condition, and whether the control of sepsis is possible in with I&D with concomitant modern antibiotics, and to compare post-operative healing time between I&D with deroofing versus saucerization in the treatment of carbuncle. Our continued practice of such a radical approach needs to be validated or changed aptly according to current clinical evidence. We hope this study will contribute towards an updated data in the current best surgical practice for carbuncle.

MATERIALS AND METHODS

Study Design

A prospective study was conducted in Surgical Department, Universiti Kebangsaan Malaysia Medical Centre (UKMMC) from March 2012 – March 2014 (2 years) involving 59 eligible patients. The study was ethically approved by Universiti Kebangsaan Malaysia Research & Ethics Committee (UKMREC FF-126-2012). The patients were randomized into two parallel arms (i) saucerization (control, n=23) (ii) I&D with deroofing (intervention, n=21). We assigned saucerization as the control group to reflect current local standard of practice. Randomization was performed using sequentially numbered, opaque and sealed envelopes (SNOSEs) method. Patients were consented for both procedures and blinded with regards to the allocated procedure. This process was repeated until the required number of subjects was achieved. The inclusion criteria were defined as the following: age 18-75 years, clinical diagnosis of carbuncle, surgical treatment deemed necessary, fit for general anesthesia, truncal lesion including the neck area, size of visible lesion > 1cm and < 20cm with minimum dimension 1cm2 and maximum dimension 400cm2. The exclusion criteria were defined as: necrotizing fasciitis based on clinical suspicion, limbs / perianal / perineal / pilonidal abscesses, and conservative management. The primary outcome was healing time (days). Secondary outcomes were length of hospitalization (days), dressing requirement (days), rates of complications, operating times (minutes) and bacterial growth pattern from swab cultures.

Sample Size

There was no previous published study comparing post-operative healing time of carbuncle after saucerization versus I&D with deroofing. Hence, in this study we based our calculation for sample size on mean healing time from randomized control trials of pilonidal abscess and other skin abscesses treated with saucerization [6, 7] and I&D ± deroofing [8, 9] (Table 1).

Table 1 Published reports on estimated wound healing time from saucerization and incision and drainage (I&D) ± deroofing for pilonidal abscess and other skin abscesses

Author	Study population	Mean healing time
Kronborg et al [6]	Wide excision with healing by secondary intention of pilonidal abscess	63 days ± 7days
Al-Hassan et al [7]	Wide excision of pilonidal sinus	91 days
Eryilmaz et el [8]	Healing time with incision & drainage of pilonidal abscess	19 days
Sørensen et al [9]	Healing time for deroofing and drainage of subcutaneous abscess	15 days

From these studies, the difference in population means (d) was estimated at 44 days and the standard deviation (s) was estimated at 7 days. The calculated sample size would be 2 patients for each group (difference of population means (d) = 44, standard deviation (s) = 7 days, power of study 1-β= 0.8 with α = 0.05 significant level, Constant, C=7.85). The calculated sample size was small due to the wide difference of healing time between the two procedures. We postulated that the healing time for carbuncle wound was likely to be diverse based on the different sizes of carbuncles at presentation compared to pilonidal abscesses and therefore, we decided to detect a clinically significant difference at 1 month (28 days) instead with a standard deviation of 4 weeks (28 days). Therefore, with the presumed clinically significant difference of population means (d) = 28 days, an estimated population standard deviation (s)= 28 days, power of study 1-β= 0.8 with α = 0.05 significant level, (Constant, C= 7.85), we calculated the sample size to be 17 for each arm and a total of 34 overall. The sample size calculation is repeated using the PS (Power and sample size calculations) software Version 3.0.34 which yielded similar sample size

calculation. Given potential drop-out rate of 20%, a sample size of 42 patients (21 patients for each arm) was required for the study.

Statistical Analysis

All analysis was performed based on intention to treat. Continuous variables were compared using the paired T-test for independent sample. Where distributions were skewed and logarithmic transformation did not increase normality, the Mann Whitney test was applied. Differences in categorical variables were compared using the Chi square test. The significance level was set at $p < 0.05$. All analysis was conducted using statistical software SPSS version 21.0 (IBM, Chicago, IL).

Data Collection

The following baseline data were collected upon recruitment: (i) age, gender, race (ii) co-morbidities (iii) drug history (iv) pre-procedure hemoglobin (Hb) and total white cell count (TWC) (v) admission vital signs – temperature and blood sugar (vi) size and site of carbuncle (vii) intra-operative duration (minutes) (viii) estimated intra-operative blood loss (mls) (ix) blood transfusion requirement (x) antibiotics therapy (xi) microbiology culture result (xii) duration of hospitalization. Upon out-patient follow up, the following data were collected: (i) wound healing assessment (ii) any complications (iii) days requiring change of dressing. Would healing was assessed and documented at 2 weeks, 1, 2 and 3 months interval by an independent assessor in surgical out-patient clinic. Earlier follow up was arranged if wound was deemed likely to heal before the next scheduled visit. Wound was assessed every 2 weeks thereafter if complete healing was yet to occur after 3 months. The number of total days of dressing required and complications were recorded at each visit. Microbiology investigations with swab culture and sensitivity (C&S) were repeated at one-month follow up.

Definition of Terms

Healing time was defined as the number of days required for complete wound healing with complete epithelization without sign of infection [10]. Post-operative complication was defined as any significant negative / adverse event perceived by either the surgeons or the patients after surgery, including hematoma, bleeding, failure of sepsis resolution after 48 hours, new necrosis or significant tissue sloughing requiring further debridement. All complications were recorded up to 30 days post-operatively and documented during out-patient follow up. Hospital stay was measured from the day of operation until the day of discharge. Days requiring change of dressing was calculated from the day of operation until the day that dressing was no longer required. Dressing was defined as any form of absorbent material used to dress a wet wound. Choice and type of dressings were not restricted. If re-dressing was required, the duration would be included into the final total days for analysis.

Procedures

The admitting on-call surgeons were briefed on the study protocol and instructed on the techniques of deroofing with I+D. The operative procedure was straightforward and unlikely to cause expertise bias. To the surgeon and independent wound assessor, blinding was not possible as the techniques and wound / scars were visibly different. All procedures were performed under general anesthesia. Patients were positioned to allow best surgical access. All patients received skin preparation with providone iodine 10% or chlorhexidine 2% unless allergy to iodine was documented. All patients received intravenous unasyn 1.5g (1g ampicilin and 0.5g sulbactam) as pre-operatively and converted to oral form for 5 days post-operatively. All pus / tissue samples were sent for culture and sensitivity. Hemostasis was achieved using compression, diathermy and / or suture as necessary. All wounds were cleaned with hydrogen peroxide 6% followed with generous wash with 0.9% saline. Cavities were packed with povidone-soaked gauze/or ribbon gauze and

covered with dry gamgee and plastered to skin. All wounds were reviewed at Day 1 post-operatively. Daily dressing was performed for all patients until clinically deemed no longer necessary by the attending surgeon. Dressing regime were performed in accordance with standard institutional nursing procedure.

Intervention Group I&D with Deroofing

Appropriate incision was made to excise any unhealthy tissue and to de-roof the abscess (Figure 1). The choice of incision was based with the aim to debride all unhealthy tissue with maximal conservation of viable tissue. Discharging openings were excised. Pus was drained and all loculations were broken down. Compulsory curettage was performed to remove debris from cavities [11]. Cellulitic areas were spared.

Figure 1 A carbuncle with illustrated black line to demonstrate incisional and drainage (I&D) with deroofing approach

Control Group

A circumferential incision was made along the border of cellulitic margin (Figure 2). Lesion was excised in its entirety until normal healthy tissue margin was achieved.

Figure 2 A carbuncle with illustrated black line to demonstrate saucerization approach

RESULTS

The study algorithm is shown in Figure 3. A total of 59 patients were identified for recruitment during the 24 months period. Fifteen patients were excluded from the study due to inability to consent (n=1), refusal (n=3) and presence of exclusion criteria (n=11). A total of 44 patients were eligible for randomization into control group saucerization (n=23) and intervention group I&D with deroofing (n=21). At the end of study period, one patient from saucerization arm was lost to follow up. The study was conducted and reported according to the consolidated standards of reporting trials (CONSORT) statement.

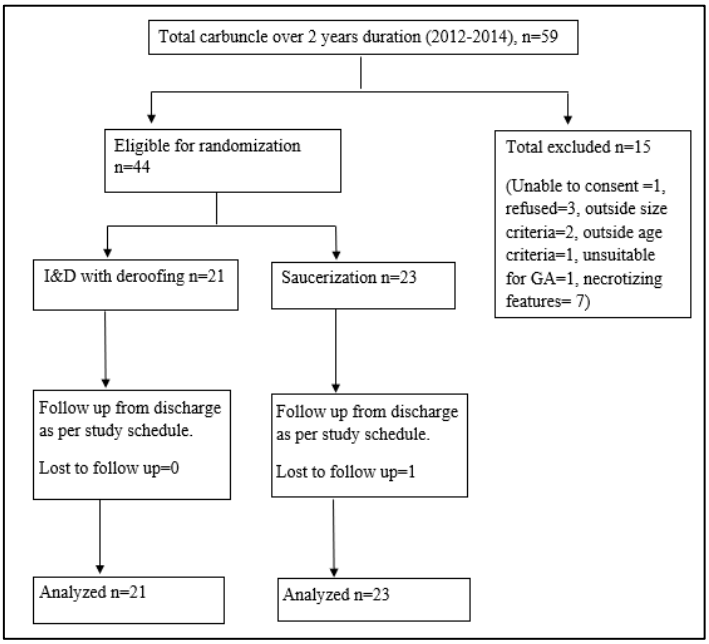

Figure 3 Study algorithm of carbuncle patients in Universiti Kebangsaan Malaysia Medical Center between March 2012 – March 2014

Patients' Characteristics

The patients' characteristics and comparison in the two arms are summarized Table 2. The median age of patients was comparable in both arms with 56 years in I&D with deroofing arm (IQR 33-77) and 52 years in the saucerization arm (IQR 26-80) and was not statistically significant (p=0.916). More males were assigned to saucerization arm (18/23, 78.3%) compared to I&D with deroofing (13/21, 61.9%) and was statistically significant (p=0.013). More cigarette smokers were assigned to I&D with deroofing arm (7/13, 53.8%) compared to saucerization arm (6/18,33.3%) but not statistically significant (p=0.063). Our patient cohort was classified as overweight (body mass index BMI 25-29 kg/m2) and were comparable across the two arms with a median 26.2 kg/m2 in I&D with deroofing arm (IQR18-45) and 25.9 kg/m2 in saucerization arm (IQR 21-35); p=0.664. The height distribution was significant (p=0.025) with median height 1.64m in saucerization arm (IQR1-2) compared to 1.60m in I&D with deroofing arm (IQR 1-2). The median baseline Hb was comparable in both arms (13.5g/dL in I&D with deroofing arm (IQR 11-17); 13.4g/dL in saucerization arm (10-16); p=0.459). The median TWC was quantitatively higher at 15.4 x 109/L (IQR 5-36) in the saucerization group inferring worse sepsis compared to 13.4 x 109/L (IQR 6-30) in the I&D with deroofing arm, however, was not statistically significant (p=0.341). Random bedside blood sugar level was taken as a surrogate marker on patient's sugar control upon admission. The median random glucose levels on both arms were quantitatively higher than normal (10.8 mmol/L in I&D with deroofing arm (IQR 3-32), 15.9 mmol/L in the saucerization arm (IQR 2-26)) but not statistically significant (p=0.658). The median

size of carbuncle was 30cm2 for the I&D with deroofing arm (IQR 9-225) and 32cm2 for the saucerization arm (IQR 4-225) and not statistically significant (p=0.981). Only one patient in the saucerization arm required blood transfusion intra-operatively and not statistically significant (p=1.0). The median operation times between the two surgical procedures were similar at 30 minutes but statistically significant (p=0.01) given a higher interquartile range (IQR) in saucerization arm (IQR 20-125) compared to I&D with deroofing (IQR 15-45). Using descriptive analysis, the median operation times for I&D with deroofing arm was 27.00 ± 8.92 minutes, considerably much shorter than 43.04 ± 8.92 minutes in saucerization arm. The prevalence of chronic co-morbidities such as diabetes mellitus, hypertension, ischemic heart disease, chronic obstructive pulmonary disease and chronic kidney disease across the two arms were relatively similar and not statistically different.

Table 2 Patients' characteristics and their comparison between incision and drainage (I&D) with deroofing arm versus saucerization arm

Variables	I&D with deroofing (n=21)	Saucerization (n=23)	p-value
Socio-demographic			
[a]Age, years	56.00(33,77)	52.00(26,80)	0.916
[b]Gender**			
Male	13(61.9)	18(78.3)	0.013*
Female	8(38.1)	5(21.7)	
Smoking status**	7/13 (53.8)	6/18(33.3)	0.063
Clinical characteristic			
[a]Height (meter)	1.60(1,2)	1.64(1,2)	0.025*
[a]Weight (kg)	67.00(45,102)	70.00(55,93)	0.452
[a]Body Mass Index BMI (kg/m^2)	26.22(18,45)	25.91(21,35)	0.664
[a]Hemoglobin (g/dl)	13.50(11,17)	13.40(10,16)	0.459
[a]Total White Cell TWC (10^9/dl)	13.40(6,30)	15.40(5,36)	0.341
[a]Blood glucose on admission (mmol/L)	10.80(3,32)	15.90(2,26)	0.648
[a]Size of carbuncle (cm^2)	30(9,225)	32(4,225)	0.981
[c]Transfusion requirement**			
Yes	0 (0.0)	1 (4.3)	1.000
No	21 (100.0)	22 (95.7)	
Operation duration (min)	30(15,45)	30(20,125)	0.010*
Co-morbidities			
[b]Hypertension	10(47.6)	15(65.2)	0.239
[c]Diabetes Mellitus	18(85.7)	17(73.7)	0.552
[c]Ischemic Heart Disease	0(0.0)	3(17.0)	0.265
[c]Chronic Obstructive Pulmonary Disease	1(4.8)	0(0.0)	0.363
[c]Chronic Kidney Disease	0(0.0)	1(4.3)	1.000

All data are expressed as median
** Data expressed as n (%)
IQR: Inter-quartile range
a: Mann-Whitney U test
b: Chi-square test
c: Chi-square with continuity correction
*: significant if p-value < 0.05

Primary and Secondary Outcomes

For primary outcome, I&D with deroofing was significantly associated with shorter healing time (p=0.003) with median 28 days (IQR 10-84) compared to median of 72 days (IQR 14-168) in saucerization arm (Table 3). For secondary outcome, I&D with deroofing was also significantly associated with less days requiring change of dressing (p=0.002) with median 28 days (IQR 10-84) compared to median of 77.5 days (IQR 14-168) in saucerization arm.

There was a lower percentage of complications in I&D with deroofing approach (3/21, 14.3%) compared to saucerization approach (4/23,17.4%). However, it was not statistically significant, and neither was the length of hospital stay between the two surgical approaches. Further analysis of post-operative complications showed that 3/21 patients from I&D with deroofing arm required further de-sloughing under local anesthesia (LA) (Table 4). In the saucerization arm, 2 patients required further de-sloughing under LA, one patient required further debridement under general anesthesia (GA) due to new non-viable tissue, and one patient required blood transfusion due to significant intra-operative blood loss. We observed a shorter median operating time of I&D with deroofing procedure compared to saucerization (27.00 ± 8.92 mins vs 43.04 ± 8.92 mins). However, in a critically ill patient with significant co-morbidities and a high GA risk, a shorter operating time could potentially have a positive impact on post-operative recovery and outcome. The observed difference in operating time was deemed small, however more data would be required to determine the true association between the surgical approach with shortening of operating time.

Table 3 Results of primary outcome (complete healing time) and secondary outcomes (days requiring change of dressing, length of hospital stay, complications) between incision and drainage (I&D) with deroofing and saucerization for the treatment of carbuncle

Variables	I&D with deroofing (n=21)	Saucerization (n=23)	p-value
Primary outcome			
[a]Complete healing time (days)	28(10,84)	72(14,168)	0.003*
Secondary outcome			
[a]Days requiring change of dressing	28(10,84)	77.50(14,168)	0.002*
[a]Hospital stay (days)	1(1,6)	2(1,11)	0.412
[c]Complications**			
Yes	3 (14.3)	4 (17.4)	0.781
No	18 (85.7)	19 (82.6)	

All data are expressed as median
** Data expressed as n (%)
IQR: Inter-quartile range
a: Mann-Whitney U test
b: Chi-square test
c: Chi-square with continuity correction
*: significant if p-value < 0.05

Table 4 Summary of secondary outcomes of post-operative complications rates between incision and drainage (I&D) with deroofing and saucerization for the treatment of carbuncle

Incisional and drainage with deroofing n=3/21	Saucerization n=4/23
3 patients required further de-sloughing under local anesthesia	2 patients required further de-sloughing under local anesthesia 1 patient required further debridement under general anesthesia (new non-viable tissue) 1 patient required blood transfusion due to significant intra-operative blood loss

In the I&D with deroofing arm, the commonest bacteria grown from swab cultures was *Staphylococcus aureus* (57%), followed by *Streptococcus viridans* (5%) and *Pseudomonas spp* (5%) while no bacterial growth was detected in the remaining 33% (Figure 4). In the saucerization arm, the commonest bacteria grown from swab cultures was *Staphylococcus aureus* (61%), followed by *Enterobacter spp* (5%), *Klebsiella spp* (4%), mixed growth of *Staphylococcus / Enterobacter / Klebsiella* (4%) while no results were available in the remaining 4% of patients. Overall, both arms demonstrated comparable and similar percentages of *Staphylococcus aureus* as the main infective organism. Mixed organisms (*Staphylococcus aureus, Enterobacter spp, Klebsiella spp*) were detected from a patient with diabetes mellitus from saucerization arm.

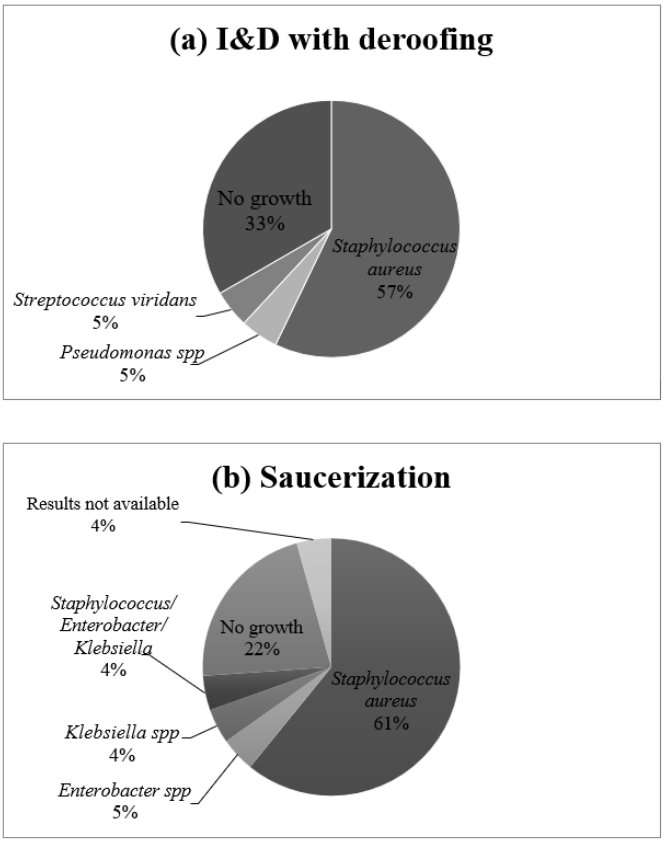

Figure 4 Pie chart showing types of bacteria growth from swab cultures from (a) incision and drainage (I&D) with deroofing and (b) saucerization for the treatment of carbuncle

DISCUSSION

One of the major findings in this study was significantly shorter and almost 2.5 times faster healing time in I&D with deroofing approach compared to saucerization. I&D procedure is known to produce faster healing via superior skin conservation and rapid epithelialization. Although this finding was already anticipated based on existing surgical knowledge, but it has not been studied in a carbuncle cohort via a randomized study. Despite the small sample size, this finding was in agreement with other published studies comparing I&D procedure with wide excision approach [6-9].

Prolonged post-operative recovery with longer healing time has a direct socio-economic impact on patients' lives via higher wound care cost and more days off from work [6], and negative effect on physical and psychological well-being [12, 13]. The large healing time difference of six weeks between the

two surgical approaches highlighted that I&D with deroofing was a better option in terms of shorter post-operative recovery and cost-effective healthcare.

Although I&D with deroofing for carbuncles was significantly associated with shorter healing time compared to saucerization technique, the median value of 28 days was observed to be considerably prolonged than the reported healing times of 12-19 days in I&D for other cutaneous abscesses [6-8]. On the other hand, the median value of 72 days in our saucerization arm was more homogeneous with other published healing time of 67-91 days [9]. The variation observed could be due to differences in dressing care practices / products available in the community, or limitation in study design resulting in non-standardized post-operative dressing procedure and monitoring.

We found that I&D with deroofing approach was associated with a reduction in dressing requirement. We believe that this finding would also lead to an overall reduction in healthcare cost with less use of dressing materials and other resources such as nursing care and clinic visit time. Although our study was not powered to perform cost effectiveness sub-analysis, this aspect would be an interesting area for future research.

Although the rates of complications from both surgical approaches were observed to be high at 14.3% and 17.4% respectively, their severity were minor. Three patients from each groups required further de-sloughing or debridement, five under LA and one under GA. One patient from the saucerization arm who required blood transfusion intra-operatively due to excessive blood loss initially presented with a large carbuncle requiring wide and extensive excision margin. Intra-operative hemorrhage during saucerization is a known complication but there was no published incidence rate in the literature. Here, we demonstrated a risk of 4.3% (1/23) in blood transfusion requirement with saucerization approach.

All patients in both arms were comparable in terms of age group, BMI, smoking status, carbuncle lesion size, sugar control, prevalence of diabetes mellitus and risk factors associated with wound healing. Diabetes mellitus is of particular importance as vasculopathy, neuropathy and immunosuppression are known to impair wound healing and HbA1c level is a good predictor of wound healing rate [14]. HbA1c levels and diabetic control would be good parameters to study to determine carbuncle outcome in future research.

Sepsis resolution is an area of great concern with regards to incisional procedure. Variable parameters e.g. physiological or biochemical markers or end points e.g. mortality have been used previously to measure sepsis outcome. This study was limited in comparing post-operative sepsis resolution between the two surgical approaches. However, our primary outcome in complete wound healing served as a strong surrogate indicator of sepsis resolution, as supported by definition of wound healing as complete epithelialization in the absence of sepsis, suggesting that at the time when wound has healed, sepsis has also resolved. Hence, we cautiously extrapolate that, given that wound healing was significantly faster in the I&D with deroofing arm compared to saucerization arm, sepsis resolution in the I&D with deroofing arm was at least not worse than the saucerization arm. However, the study was limited in demonstrating how early the sepsis resolution occurred. Physiologically, saucerization would result in earlier sepsis resolution but prolonged healing process, and vice versa for I&D with deroofing. This expected observation, however, remains a suggestive deduction.

Limitation of Study

Carbuncle can be diagnostically challenging. Clinically, carbuncle rarely presents as a single pathology, but as a spectrum of soft tissue infection with varying severity from a simple cellulitis to necrotizing fasciitis. This factor has complicated the recruitment process, as a necrotizing infection will require a more aggressive and radical debridement. A complicated soft tissue abscess such as carbuncle is recommended to be treated with I&D (2B recommendation), while any necrotizing component should be managed with prompt debridement (1C recommendation) [15]. More than usual, the necrotizing element was not evident until excision had been performed. Seven patients with clinically suspicious necrotizing features were excluded from recruitment, and subsequently we did not encounter any necrotizing features during excision.

Carbuncle is less popular amongst the scientific community with very few updated publications. When available, most of these data were confined to individual reviews, experimental reports or case series. Carbunculosis was usually studied as part of soft tissue infection spectrum rather than as a single pathology. Additionally, given the small sample size, it will be difficult to compare our results to the current and limited published literatures. Between 1880s and 1950s, there were a few interesting publications in the treatment of carbuncle such as local antibiotic injection and radiotherapy [19, 20]. Beyond 1950, the publications on carbuncle declined with the broad emergent of penicillin as an anti-infective treatment.

CONCLUSION

Saucerization is a common surgical approach in Malaysia. Its origin as the treatment of carbuncle is not entirely clear, but it might have stemmed from a radical excisional procedure. Its role as the main treatment of carbuncle as opposed to I&D in the present days needs to be re-evaluated, in keeping with recent data and international guidelines. Despite study limitations, we demonstrated that I&D with deroofing approach for the treatment of carbuncle resulted in significantly shorter healing time and less days requiring change of dressing, without any additional risks as compared to saucerization. Compared to I&D with deroofing approach, higher rates of complications with saucerization approach were observed, such as blood transfusion, although this observation was not statistically significant. The operating time in I&D with deroofing was observed to be shorter than saucerization arm, which was desirable especially in ill patients with co-morbidities and anesthetic risks, but more data will be required to demonstrate its statistical significance.

Based on our result, we propose that I&D with deroofing to be the surgical treatment of choice for carbuncle. In presence of clinical suspicion or intra-operative findings of necrotizing element, the I&D procedure should be extended to extensive debridement, in line with current international recommendation. There is no evidence in our study or in the current literature review to support continued practice of saucerization as the treatment for carbuncle.

In future, carbuncle may be researched further with a bigger sample size so that further analysis can be performed such as the effects of age, diabetes, different incisional approach (e.g.linear or cruciate) and sizes of carbuncle on rate of wound healing, speed of sepsis resolution and cost effectiveness between the two procedures.

CONFLICT OF INTEREST

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests.

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Ethical Approval

This study was approved by the Universiti Kebangsaan Malaysia Research and Ethics Committee (UKMREC) FF-126-2012

AUTHORS' CONTRIBUTIONS

All authors contributed to study design, data collection, data analysis, manuscript writing, editing and approved the final version of the manuscript.

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