SK dan Laporan Hibah Kompetitif Nasional Penelitian Terapan Unggulan Perguruan Tinggi (PTUPT) DRPM Tahun 2019

(Mulai tahun 2019 terjadi perubahan format template usulan dan laporan akhir penelitian DRPM tidak ada lembar pengesahan)

(6) Yunita Sari, S.Kep., Ns., MHS., Ph D

KEMENTERIAN RISET, TEKNOLOGI, DAN PENDIDIKAN TINGGI
UNIVERSITAS JENDERAL SOEDIRMAN
LEMBAGA PENELITIAN DAN PENGABDIAN KEPADA MASYARAKAT
Jl. Dr.Suparno Grendeng Purwokerto 53122 Telpon/Fax (0281) 625739
Website : lppm.unsoed.ac.id dan email : lppm_unsoed@yahoo.co.id

KEPUTUSAN
KETUA LEMBAGA PENELITIAN DAN PENGABDIAN KEPADA MASYARAKAT
UNIVERSITAS JENDERAL SOEDIRMAN
Nomor : Kept.112/UN23.14/PN.01.00/2019

Tentang
PELAKSANA PENELITIAN TERAPAN UNGGULAN PERGURUAN TINGGI
UNIVERSITAS JENDERAL SOEDIRMAN TAHUN ANGGARAN 2019

KETUA LEMBAGA PENELITIAN DAN PENGABDIAN KEPADA MASYARAKAT
UNIVERSITAS JENDERAL SOEDIRMAN

Menimbang :
a. bahwa perguruan tinggi mempunyai tugas menyelenggarakan pendidikan, penelitian, dan pengabdian kepada masyarakat;
b. bahwa untuk memenuhi kualitas dan kuantitas penelitian di Universitas Jenderal Soedirman, maka perlu dilakukan penelitian secara kompetitif dan memenuhi standar mutu
c. Bahwa untuk itu perlu diangkat pelaksana Penelitian Terapan Unggulan Perguruan Tinggi dengan Surat Keputusan Ketua Lembaga Penelitian dan Pengabdian kepada Masyarakat Universitas Jenderal Soedirman.

Mengingat :
1. Undang-undang RI Nomor 5 Tahun 2014 tentang Aparatur Sipil Negara;
2. Undang-undang RI Nomor 20 Tahun 2003 tentang Sistem Pendidikan Nasional;
3. Undang-undang RI Nomor12 Tahun 2012 tentang Pendidikan Tinggi;
4. Peraturan Pemerintah RI Nomor 17 Tahun 2010 jo Nomor 66 Tahun 2010 tentang Pengelolaan dan Penyelenggaraan Pendidikan;
5. Keputusan Presiden Republik Indonesia Nomor 195 Tahun 1963 jo Kept. Menteri PTIP No. 153 Tahun 1963 tentang Pendirian Unsoed;
6. Peraturan Menteri Riset, Teknologi, dan Pendidikan Tinggi Nomor 28/2017 tanggal 10 April 2017 tentang Statuta Universitas Jenderal Soedirman;
7. Peraturan Menteri Riset, Teknologi, dan Pendidikan Tinggi Nomor 10 Tahun 2016 tentang Organisasi dan Tata Kerja Unsoed jo Nomor 23 Tahun 2017 tanggal 3 Maret 2017;
8. Peraturan Menteri Keuangan Nomor 60/PMK.02/2018 tentang Persetujuan Kontrak Tahun Jamak oleh Menteri Keuangan;
9. Peraturan Menteri Keuangan RI Nomor 69/PMK.02/2018 tentang Standar Biaya Keluaran (SBK) Tahun Anggaran 2019;
10. Keputusan Menteri Riset, Teknologi, dan Pendidikan Tinggi RI Nomor 222/M/KPT.KP/2018 tanggal 30 April 2018 tentang Pemberhentian dan Pengangkatan Rektor Universitas Jenderal Soedirman Periode 2018 – 2022;
11. SK Rektor Unsoed No. Kept. 175/UN23/KP.02.02/2019 tanggal 4 Februari 2019 tentang Pemberhentian dan Pengangkatan Ketua Lembaga Penelitian dan Pengabdian Kepada Masyarakat periode 2019-2023;

12. Kontrak Penelitian Tahun 2019 antara Direktur Riset dan Pengabdian Masyarakat, Direktorat Jenderal Penguatan Riset dan Pengembangan, Kementerian Riset, Teknologi, dan Pendidikan Tinggi dengan Ketua Lembaga Penelitian dan Pengabdian Kepada Masyarakat Unsoed Nomor 062/SP2H/LT/DRPM/2019, 176/SP2H/LT/DRPM/2019,

MEMUTUSKAN

Menetapkan : KEPUTUSAN KETUA LEMBAGA PENELITIAN DAN PENGABDIAN KEPADA MASYARAKAT UNIVERSITAS JENDERAL SOEDIRMAN TENTANG PELAKSANA PENELITIAN TERAPAN UNGGULAN PERGURUAN TINGGI UNIVERSITAS JENDERAL SOEDIRMAN TAHUN ANGGARAN 2019.

KESATU : Menugaskan kepada dosen yang namanya tercantum dalam lampiran keputusan ini untuk melaksanakan penelitian yang judul, biaya, waktu dan tugas dalam penelitian masing-masing termaktub dalam surat keputusan ini selanjutnya disebut "Peneliti"

KEDUA : Dalam melaksanakan tugasnya "Peneliti" membuat laporan dan bertanggung jawab kepada Ketua Lembaga Penelitian dan Pengabdian Kepada Masyarakat Universitas Jenderal Soedirman.

KETIGA : Penelitian dilakukan selama 8 (delapan) bulan mulai 12 Maret 2019 sampai dengan 15 Nopember 2019

KEEMPAT Biaya pelaksanaan penelitian dibebankan kepada DIPA Direktorat Penelitian dan Pengabdian Masyarakat Kementerian Riset, Teknologi, dan Pendidkan Tinggi.

KELIMA Keputusan ini berlaku sejak tanggal ditetapkan.

Ditetapkan di Purwokerto
Pada tanggal, 12 Maret 2019

Ketua,

RIFDA NAUFALIN
NIP. 19701121199512 2 001

-lppm/unsoed/dyt

Lampiran : Surat Keputusan Ketua LPPM Universitas Jenderal Soedirman
Nomor Kept. :112/UN23.14/PN.01.00/2019 tanggal 12 Maret 2019
Pelaksana Penelitian Terapan Unggulan Perguruan Tinggi
Universitas Jenderal Soedirman Tahun Anggaran 2019

No	Personalia	Jabatan	Judul Penelitian	Dana Disetujui (Rp)	Biaya Tambahan (Rp)	Fakultas
1	Dr. Denok Kurniasih, M.Si. Prof. Dr. Paulus Israwan Setyoko, M.S. Drs. Moh. Imron, M.Si.	Ketua Peneliti Anggota Peneliti I Anggota Peneliti II	Pendekatan Good Corporate Governance Untuk Model Pengelolaan Badan Usaha Milik Desa (BUMDes) di Kabupaten Banyumas	65.092.500	-	Ilmu Sosial dan Ilmu Politik
2	Dr. Warsinah, Apt, M.Si Hanif Nasiatul Baroroh, M.Sc.Apt.	Ketua Peneliti Anggota Peneliti I	Isolasi Senyawa Agen Kemopreventif Dan Kemoterapi Penyakit Kanker Payudara dari Herba Babandotan (*Ageratum Conyzoides L)*	117.600.000	15.000.000	Ilmu Kesehatan
3	Prof. Dr. Ir. Suwarto, MS Ir. Imastini Dinuriah, Grad.Dip.Sc., M.Sc.	Ketua Peneliti Anggota Peneliti I	Pembentukan Varietas Green Super Rice Untuk Meningkatkan Produksi Padi Pada Lahan Marjinal	96.500.000	-	Pertanian
4	Dr. Ir. Heru Adi Djatmiko, M.P. Dr. Ir. Nur Prihatiningsih, M.S. Dr. Ir. Ismangil, M.S.	Ketua Peneliti Anggota Peneliti I Anggota Peneliti II	Pengayaan Pupuk Organik Cair Dengan Bacillus Subtilis B1 Untuk Pengendalian Penyakit Layu Stewart's, Peningkatan Pertumbuhan Dan Hasil Jagung Lahan Marginal	86.140.000	15.000.000	Pertanian
5	Dra. Dijan Rahajuni, M.Si Dr. Lilis Siti Badriah, S.E., M.Si Dra. Neni Widayaningsih, M.M	Ketua Peneliti Anggota Peneliti I Anggota Peneliti II	Model Pemberdayaan Masyarakat Miskin Melalui Peningkatan Nilai Ekonomi Pekarangan Dalam Rangka Mendukung Ketahanan Pangan Keluarga di Kabupaten Banyumas	81.755.000	-	Ekonomi & Bisnis

-lppm/unsoed/dyt

6	Yunita Sari, S.Kep., Ns., MHS., Ph.D Dr. dr. Eman Sutrisna, M.Kes Hartono, S.Si., M.Si	Ketua Peneliti Anggota Peneliti I Anggota Peneliti II	Potensi Alat Electrical Stimulation Portable Dengan Harga Terjangkau Untuk Mempercepat Penyembuhan Luka Diabetes	129.370.000	15.000.000	Ilmu Kesehatan
7	Ir. Juni Sumarmono, M.Sc., Ph.D Dr. Triana Setyawardani, SPt.,MP Dr. Ir. Agustinus Hantoro Djoko Rahardjo, MP.	Ketua Peneliti Anggota Peneliti I Anggota Peneliti II	Rekayasa Proses Fermentasi Untuk Meningkatkan Karakteristik Yogurt Pasta (Concentrated Yogurt) Dari Susu Sapi Sebagai Produk Makanan Fungsional	117.750.000	15.000.000	Peternakan
8	Sri Lestari, S.E., M.Si Dr . Laeli Budiarti M.Si, Ak Aldila Krisnaresanti, S.Pd., M.Pd..	Ketua Peneliti Anggota Peneliti I Anggota Peneliti II	Pengembangan Model Program Mahasiswa Wirausaha (PMW) Di Universitas Jenderal Soedirman	92.596.000	15.000.000	Ekonomi & Bisnis
9	Dr. Dyah Retna Puspita, M. Hum. Dra. Rin Rostikawati,M.Si Drs. Pawrtha Dharma, M.Si.	Ketua Peneliti Anggota Peneliti I Anggota Peneliti II	Model Penyuluhan Organisasi Pemberdayaan Dan Kesejahteraan Keluarga (PKK) Berperspektif Gender Dalam Meningkatkan Ketahanan Keluarga Di Kabupaten Cilacap	75.740.000	15.000.000	Ilmu Sosial dan Ilmu Politik
10	Dr.sc.hum. Budi Aji, SKM, M.Sc. Nur Ulfah, SKM, M.Sc Siti Masfiah, SKM, M.Kes, MA. Siti Harwanti, S.Kp., M.Kes	Ketua Peneliti Anggota Peneliti I Anggota Peneliti II	Model perluasan kepesertaan BPJS Kesehatan dan Peningkatan Akses Pelayanan Kesehatan Bagi Pekerja Sektor Informal Berbasis Pemberdayaan Koperasi	67.000.000	15.000.000	Ilmu Kesehatan

Ketua,

KEMENTERIAN RISET, TEKNOLOGI, DAN PENDIDIKAN TINGGI
UNIVERSITAS JENDERAL SOEDIRMAN
LPPM

RIFDA NAUFALIN
NIP. 19701121199512 2 001

-lppm/unsoed/dyt

LAPORAN AKHIR PENELITIAN TAHUN TUNGGAL

ID Proposal: e9bfeb14-ff95-40fb-8118-1085b6a982fc
Laporan Akhir Penelitian: tahun ke-3 dari 3 tahun

1. IDENTITAS PENELITIAN

A. JUDUL PENELITIAN

POTENSI ALAT ELECTRICAL STIMULATION PORTABLE DENGAN HARGA TERJANGKAU UNTUK MEMPERCEPAT PENYEMBUHAN LUKA DIABETES

B. BIDANG, TEMA, TOPIK, DAN RUMPUN BIDANG ILMU

Bidang Fokus RIRN / Bidang Unggulan Perguruan Tinggi	Tema	Topik (jika ada)	Rumpun Bidang Ilmu
Pangan, gizi dan kesehatan (food, nutrition and health)	-	Pangan, gizi dan kesehatan (food, nutrition and health)	Ilmu Keperawatan

C. KATEGORI, SKEMA, SBK, TARGET TKT DAN LAMA PENELITIAN

Kategori (Kompetitif Nasional/ Desentralisasi/ Penugasan)	Skema Penelitian	Strata (Dasar/ Terapan/ Pengembangan)	SBK (Dasar, Terapan, Pengembangan)	Target Akhir TKT	Lama Penelitian (Tahun)
Penelitian Desentralisasi	Penelitian Terapan Unggulan Perguruan Tinggi	SBK Riset Terapan	SBK Riset Terapan	6	3

2. IDENTITAS PENGUSUL

Nama, Peran	Perguruan Tinggi/ Institusi	Program Studi/ Bagian	Bidang Tugas	ID Sinta	H-Index
YUNITA SARI Ketua Pengusul	Universitas Jenderal Soedirman	Ilmu Keperawatan		5973059	6
Dr. Dr EMAN SUTRISNA S.Ked, M.Kes Anggota Pengusul 1	Universitas Jenderal Soedirman	Profesi Dokter		6143843	0
HARTONO M.Si Anggota Pengusul 2	Universitas Jenderal Soedirman	Fisika		0	0

3. MITRA KERJASAMA PENELITIAN (JIKA ADA)

Pelaksanaan penelitian dapat melibatkan mitra kerjasama, yaitu mitra kerjasama dalam melaksanakan penelitian, mitra sebagai calon pengguna hasil penelitian, atau mitra investor

Mitra	Nama Mitra
Mitra Calon Pengguna	kelompok peduli diabetes
Mitra Calon Pengguna	Griya farah wound care

4. LUARAN DAN TARGET CAPAIAN

Luaran Wajib

Tahun Luaran	Jenis Luaran	Status target capaian (*accepted, published, terdaftar atau granted, atau status lainnya*)	Keterangan (*url dan nama jurnal, penerbit, url paten, keterangan sejenis lainnya*)
3	Dokumentasi hasil uji coba produk	Ada	-

Luaran Tambahan

Tahun Luaran	Jenis Luaran	Status target capaian (*accepted, published, terdaftar atau granted, atau status lainnya*)	Keterangan (*url dan nama jurnal, penerbit, url paten, keterangan sejenis lainnya*)
3	Publikasi Ilmiah Jurnal Internasional	accepted/published	wound repair and regeneration
3	Buku Ajar (ISBN)	sudah terbit	buku ajar berjudul perawatan luka
3	Produk	penerapan	penerapan ES pada subyek manusia
3	Prosiding dalam pertemuan ilmiah Internasional	sudah terbit/sudah dilaksanakan	ICMA (international conference on multidisciplinary approach)

5. ANGGARAN

Rencana anggaran biaya penelitian mengacu pada PMK yang berlaku dengan besaran minimum dan maksimum sebagaimana diatur pada buku Panduan Penelitian dan Pengabdian kepada Masyarakat Edisi 12.

Total RAB 3 Tahun Rp. 129,370,000

Tahun 1 Total Rp. 0

Tahun 2 Total Rp. 0

Tahun 3 Total Rp. 129,370,000

Jenis Pembelanjaan	Item	Satuan	Vol.	Biaya Satuan	Total
Analisis Data	HR Pengolah Data	P (penelitian)	3	4,000,000	12,000,000
Analisis Data	Biaya analisis sampel	Unit	110	94,000	10,340,000
Bahan	ATK	Paket	10	653,000	6,530,000
Bahan	Bahan Penelitian (Habis Pakai)	Unit	40	950,000	38,000,000
Pelaporan, Luaran	Publikasi artikel di Jurnal	Paket	1	17,000,000	17,000,000

Jenis Pembelanjaan	Item	Satuan	Vol.	Biaya Satuan	Total
Wajib, dan Luaran Tambahan	Internasional				
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Biaya pembuatan dokumen uji produk	Paket	1	10,000,000	10,000,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Biaya penyusunan buku termasuk book chapter	Paket	1	8,000,000	8,000,000
Pengumpulan Data	HR Sekretariat/Administrasi Peneliti	OB	1	2,000,000	2,000,000
Pengumpulan Data	HR Pembantu Peneliti	OJ	3	5,000,000	15,000,000
Pengumpulan Data	Transport	OK (kali)	300	25,000	7,500,000
Sewa Peralatan	Peralatan penelitian	Unit	3	1,000,000	3,000,000

6. HASIL PENELITIAN

A. RINGKASAN: Tuliskan secara ringkas latar belakang penelitian, tujuan dan tahapan metode penelitian, luaran yang ditargetkan, serta uraian TKT penelitian.

Latar belakang

Salah satu komplikasi yang paling sering terjadi pada pasien DM adalah luka diabetes. Menurut data dari International Diabetic foot/IDF (2005), luka diabetes adalah penyebab utama dari amputasi ekstremitas bawah pada penderita DM. Bowker (2008) menyatakan bahwa pasien DM memiliki resiko amputasi sebesar 15-40 kali lipat dibandingkan dengan pasien bukan DM. Diperkirakan ada lebih satu juta amputasi di dunia pertahun karena luka diabetes. Di indonesia, 30 % dari penderita DM pernah mengalami amputasi kaki karena luka kaki diabetes (Waspadji, 2006). Banyak terapi dilakukan untuk meningkatkan penyembuhan luka diabetes. Diantaranya adalah perawatan luka dengan balutan luka yang lembab. Namun, terapi ini sering gagal, terutama pada luka yang lebar dan eksudat yang banyak . Terapi yang lain adalah terapi dengan menggunakan growth factor seperti FGF, PDGF, and EGF (Loot et.al, 2002). Namun terapi ini kurang efektif pada luka yang parah karena terapi ini tergantung pada kerja dari reseptor-reseptor yang masih ada di luka. Namun, reseptorreseptor ini telah mengalami penurunan pada luka diabetes. Menurut penelitian terdahulu, gangguan penyembuhan luka DM sebagian besar disebabkan karena adannya gangguan aliran darah ke daerah luka (Wu et al, 2007). Adanya penurunan aliran darah ini akan menghambat proses angiogenesis, yang akhirnya berpengaruh pada proses inflamasi dan proliferasi, berakibat pada memanjangnya waktu penutupan luka

(White,2007). Oleh karena itu diperlukan terapi yang dapat meningkatkan aliran darah pada pasien dengan luka DM. Beberapa dekade terakhir, Electrical Stimulation (ES) telah terbukti dapat meningkatkan aliran darah, dan banyak digunakan untuk tujuan kesehatan. Selain dapat meningkatkan aliran darah, hasil-hasil penelitian secara in vitro dan in vivo juga membuktikan bahwa ES juga dapat meningkatkan penyembuhan luka akut karena dapat meningkatkan migrasi keratinosit dan makrofag (Wang et al, 2003), menstimulasi fibroblas, meningkatkan sintesis protein dan sintesis kolagen (Bourguignon & Bourguignon, 1987, Li & Kolega, 2002), serta meningkatkan angiogenesis (Alat et.al, 2004; Zhao et al, 2004; Bai et al,, 2011, Sebastian et al, 2011). Hasil penelitian juga membuktikan bahwa ES juga dapat menurunkan inflamasi (Taskan et al, 1987; Talebi et al, 2007). Namun, alat ES untuk penyembuhan luka yang selama ini digunakan untuk penelitian ini harganya sangat mahal dan hanya ada di luar negeri, serta saat ini tidak dipasarkan di Indonesia. Ukuran dari alat

ES ini juga relatif besar sehingga kurang praktis dalam penggunaannya serta tidak mudah untuk dibawa kemana-mana oleh pasien. Selain itu, alat ES biasanya menggunakan dua elektroda yang dipasang pada sisi kanan dan kiri dari luka, sehingga ada bagian yang tidak terkena efek dari ES. Oleh karena itu, peneliti bermaksud untuk membuat alat ES dari bahan yang tersedia di Indonesia, dengan harga yang lebih ekonomis dan ukuran yang lebih praktis, serta dengan bentuk menyerupai cincin yang melingkari luka sehingga efektifitas dari alat ES dapat dioptimalkan. Untuk menciptakan evidence yang kuat dari alat ES buatan kami terhadap penyembuhan luka diabetes, peneliti akan menguji terlebih dahulu pada luka diabetes pada hewan coba sehingga perubahan yang terjadi didalam jaringan bisa jelas terlihat, sebelum diujicobakan pada manusia.

Tujuan dan tahapan metode penelitian

Penelitian ini bertujuan untuk menguji efektifitas dari alat ES yang kami buat untuk mempercepat penyembuhan luka diabetes.

Tujuan khusus dari penelitian ini adalah untuk:

1) Merancang prototipe alat electrical stimulation
2) Menguji prototipe pada luka yang dibuat pada tikus diabetes
3) Membandingkan peningkatan jaringan granulasi dan epitelialisasi, penurunan eksudat, luas luka, inflamasi dan nekrosis, tingkat angiogenesis, proliferasi, dan reepitelisasi antara kelompok yang diberikan terapi dengan kelompok kontrol (tanpa terapi ES).
4) Mengevaluasi kemampuan alat dan menyempurnakan alat
5) Menguji coba alat pada luka yang dibuat pada hewan uji dengan membandingkan waktu yang berbeda
6) Menguji alat ini pada luka diabetes pada manusia

Luaran yang ditargetkan

luaran wajib : hasil uji coba produk

luaran tambahan : buku ajar, produk, prosiding, dan artikel di jurnal internasional, artikel di jurnal terakreditasi DIKTI

uraian TKT penelitian : TKT tahun pertama 3, TKT tahun kedua 5, TKT tahun ketiga adalah 7

Hasil penelitian :

Hasil tahun pertama :

1. Pembuatan alat
2. Merevisi protopipe ES
3. Alat ES sudah selesai dibuat
4. Pilot study untuk mengetahui keamanan pada hewan coba
5. Luaran tahun pertama : produk alat ES, jurnal terakreditasi DIKTI (submitted), hak cipta (register), buku ajar (draft), presentasi di seminar internasional (sudah dilaksanakan), invited speaker (sudah dilaksanakan)

Tahun kedua :

1. Penelitian pada hewan coba untuk mengetahui waktu yang optimal.
2. Penelitian pada hewan coba untuk megetahui pengaruh ES pada reepitelisasi, inflamasi, MMP-9, dan VEGF.
3. Luaran tahun kedua : hasil uji coba ES pada hewan coba, jurnal terakreditasi DIKTI (published), hak cipta (granted), buku ajar (editing, presentasi di seminar internasional (sudah dilaksanakan), invited speaker (sudah dilaksanakan)

Tahun ketiga :

1. Mengurus uji etik dan ijin penelitan pada subyek manusia

2. Uji validitas dan reliabilitas kuesioner

3. Mendata pasien di klinik luka dan di kelompok peduli diabetes yang akan menjadi subyek penelitian

4. Melakukan penelitian eksperimen pada pasien dengan luka diabetes (50 pasien) dan kontrol (50 pasien) diikuti selama 4 bulan

5. Menganalisis data ukuran luka yang diperoleh pada eksperimen

6. Analisis jaringan jaringan granulasi, proporsi jumlah dan jenis eksudat, proporsi terowongan luka, proporsi kondisi tepi luka

7. Artikel di jurnal internasional (published), buku ajar sudah cetak, seminar internasional (presented), prosiding (published), artikel di jurnal ilmiah terakreditasi (published)

B. KATA KUNCI: Tuliskan maksimal 5 kata kunci.

diabetes , electrical stimulation, luka, penyembuhan

Pengisian poin C sampai dengan poin H mengikuti template berikut dan tidak dibatasi jumlah kata atau halaman namun disarankan seringkas mungkin. Dilarang menghapus/memodifikasi template ataupun menghapus penjelasan di setiap poin.

C. HASIL PELAKSANAAN PENELITIAN: Tuliskan secara ringkas hasil pelaksanaan penelitian yang telah dicapai sesuai tahun pelaksanaan penelitian. Penyajian dapat berupa data, hasil analisis, dan capaian luaran (wajib dan atau tambahan). Seluruh hasil atau capaian yang dilaporkan harus berkaitan dengan tahapan pelaksanaan penelitian sebagaimana direncanakan pada proposal. Penyajian data dapat berupa gambar, tabel, grafik, dan sejenisnya, serta analisis didukung dengan sumber pustaka primer yang relevan dan terkini.

Pengisian poin C sampai dengan poin H mengikuti template berikut dan tidak dibatasi jumlah kata atau halaman namun disarankan seringkas mungkin. Dilarang menghapus/memodifikasi template ataupun menghapus penjelasan di setiap poin.

C. **HASIL PELAKSANAAN PENELITIAN:** Tuliskan secara ringkas hasil pelaksanaan penelitian yang telah dicapai sesuai tahun pelaksanaan penelitian. Penyajian dapat berupa data, hasil analisis, dan capaian luaran (wajib dan atau tambahan). Seluruh hasil atau capaian yang dilaporkan harus berkaitan dengan tahapan pelaksanaan penelitian sebagaimana direncanakan pada proposal. Penyajian data dapat berupa gambar, tabel, grafik, dan sejenisnya, serta analisis didukung dengan sumber pustaka primer yang relevan dan terkini.

- Hasil tahun pertama :
  1. Pembuatan alat (tahun I)
  2. Merevisi protopipe ES (tahun I)
  3. Alat ES sudah selesai dibuat (tahun I)
  4. Pilot study untuk mengetahui keamanan pada hewan coba (tahun I)
  5. Luaran tahun pertama : produk alat ES, jurnal terakreditasi DIKTI (submitted), hak cipta (register), buku ajar (draft), presentasi di seminar internasional (sudah dilaksanakan), invited speaker (sudah dilaksanakan)

Alat stimulasi elektris

Figure 2.The application of Electrical Stimulation on wound

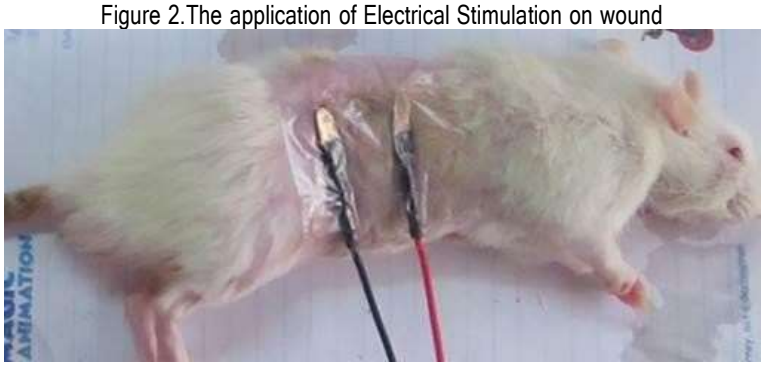


Figure 2. Electrodes were placed at the right and left of wound

Figure 3. Macroscopical findings (bar = 1 cm)

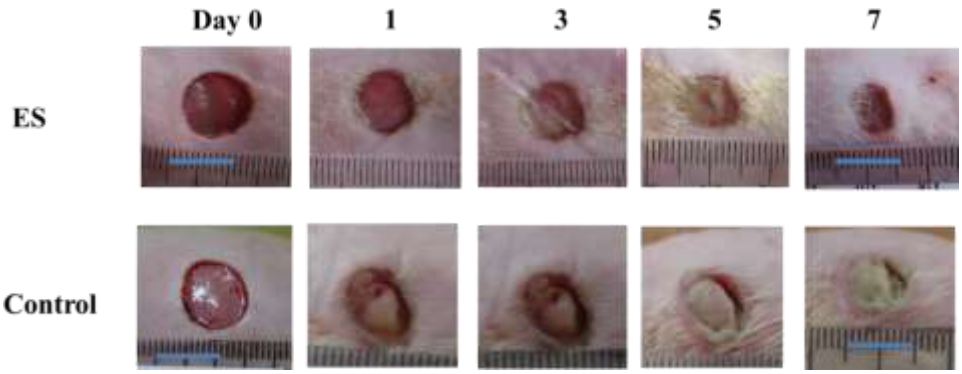


Figure 3. The difference of the macroscopical findings between ES group (Upper) and Control group (Lower)

Figure 4. Hematoxylin and Eosyn staining on day 7 in epidermis layer

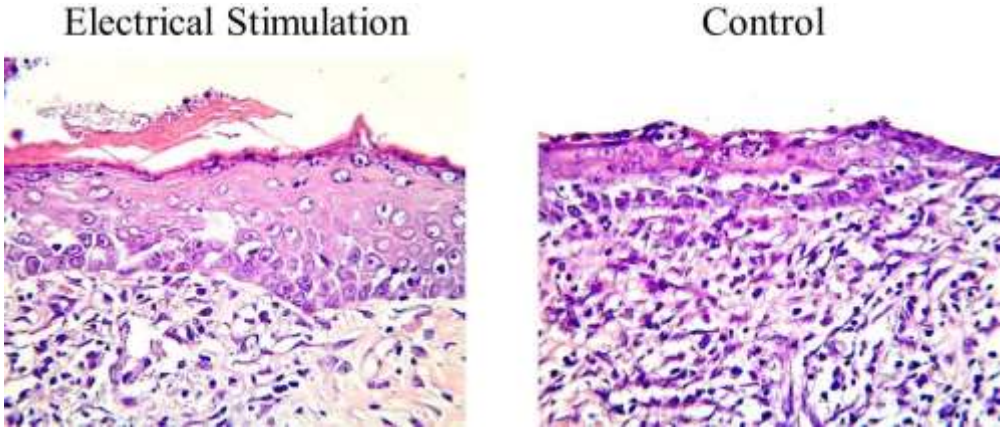


Figure 4. The difference of the Hematoxylin and Eosyn in epidermis between ES group (left) and control group (right) ((magnification of 400X)

Figure 5. Hematoxylin and Eosyn staining on day 7 in dermis layer (magnification of 400X)

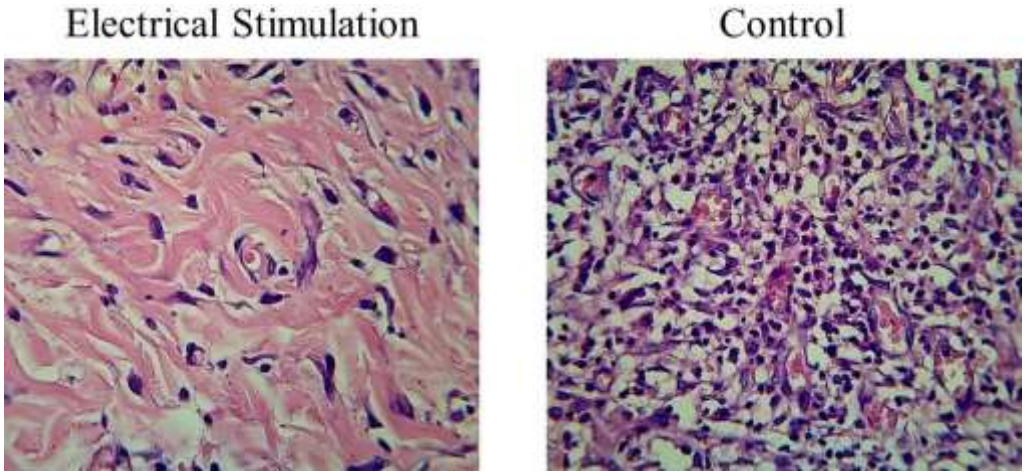


Figure 5. The difference of the Hematoxylin and Eosyn in dermis layer between ES group (left) and control group (right) (magnification of 400X)

Figure 6. Reepithelialization on wound area

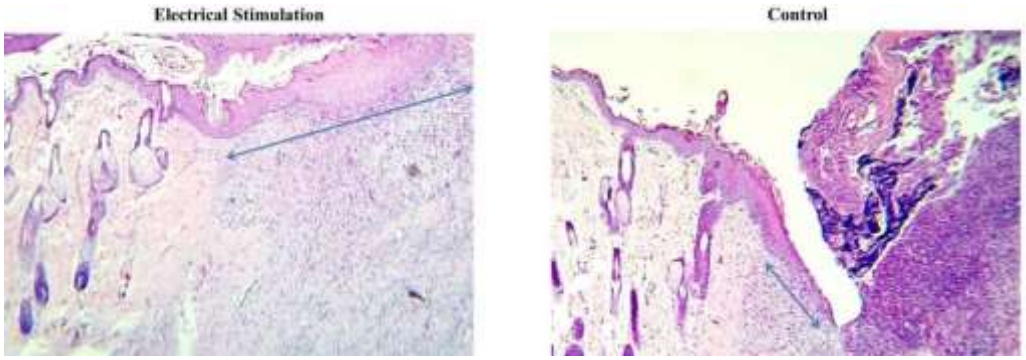


Figure 6. The difference of reepithelialization in ES and control groups (Hematoxylin and Eosyn staining, magnification of 40X)

Tables

Table 1. Summary of the histological findings of both groups on day 7

Groups	PMNs	Fibroblast
ES	2**	3*
Control	4	2

Values indicated median score

Rating scale : 0 = absent, 1= occasional, 2 = moderate, 3 = abundant, 4 = very abundant

* P < 0.05.

PMNs = polymorphonuclear neutrophils

Hasil tahun kedua

1. Penelitian pada hewan coba untuk mengetahui waktu yang optimal (tahun 2)
2. Penelitian pada hewan coba untuk megetahui pengaruh ES pada reepitelisasi, inflamasi, MMP-9, dan VEGF(tahun 2)
3. Luaran tahun kedua : hasil uji coba ES pada hewan coba, jurnal terakreditasi DIKTI (published), hak cipta (granted), buku ajar (editing, presentasi di seminar internasional (sudah dilaksanakan), invited speaker (sudah dilaksanakan)

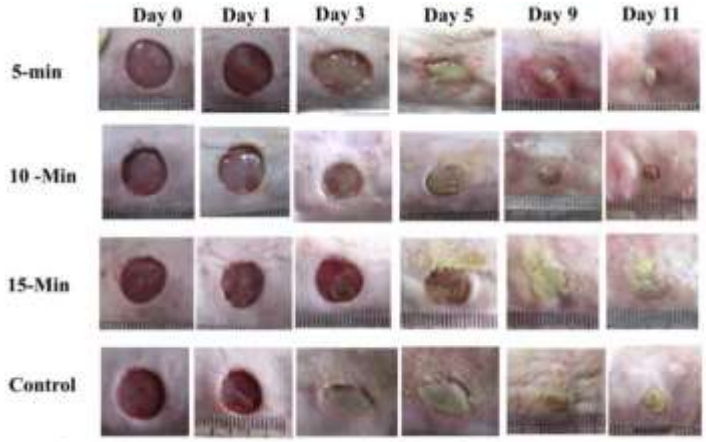


Fig. 1. Appearance of wounds in the 5-min group, 10-min group, 15-min group, and the control group (bar indicates 1 cm). Wound beds on day 11 in the 5-min, 10-min, and control groups were fully covered by necrotic tissue.

Table 1
The ratio of the wound size and initial size per group on day 0.

Days	5-min	10-min	15-min	Control
0	1.00 ± 0.00	1.00 ± 0.00	1.00 ± 0.00	1.00 ± 0.00
1	0.93 ± 0.11	0.89 ± 0.16	0.92 ± 0.13	0.91 ± 0.05
2	0.88 ± 0.10	0.83 ± 0.24	0.74 ± 0.20	0.84 ± 0.04
3	0.83 ± 0.00	0.69 ± 0.10	0.83 ± 0.22	0.68 ± 0.03
4	0.71 ± 0.18	0.63 ± .08*	0.93 ± 0.21	0.66 ± 0.05
5	0.66 ± 0.04*	0.61 ± 0.05*	0.85 ± 0.15	0.67 ± 0.01
6	0.66 ± 0.30	0.56 ± 0.03*	0.82 ± 0.14	0.60 ± 0.10
7	0.53 ± 0.20*	0.51 ± 0.10*	0.88 ± 0.23	0.58 ± 0.04
8	0.39 ± 0.26*	0.35 ± 0.16*	0.75 ± 0.13	0.42 ± 0.05*
9	0.30 ± 0.28*	0.18 ± 0.08*	0.71 ± 0.19	0.35 ± 0.14*
10	0.23 ± 0.20	0.15 ± 0.03*,†	0.58 ± 0.28	0.34 ± 0.12
11	0.22 ± 0.19	0.07 ± 0.04*,†	0.47 ± 0.27	0.28 ± 0.11

Values indicate mean ± standard deviation.
* = P < 0.05, 5-min/10-min/control group vs 15-min group.
† = P < 0.05, 5-min/10-min vs control group.

Table 2
The level of inflammation and fibroblasts per group.

Groups	Polymorphonuclear neutrophils (PMNs)	Fibroblast
5-min	2[†,*]	3[†,*]
10-min	1[*,†,*]	3.5[†,*]
15-min	4	2
Control	3[†]	2

Values represent the median score.
Rating scale: 0 = absent, 1 = occassional, 2 = moderate, 3 = abundant, 4 = very abundant.
* = p < 0.05 (10-min vs 5-min).
† = p < 0.05 (5-min/10-min/control vs 15-min).
* = p < 0.05 (5-min/10-min vs control).

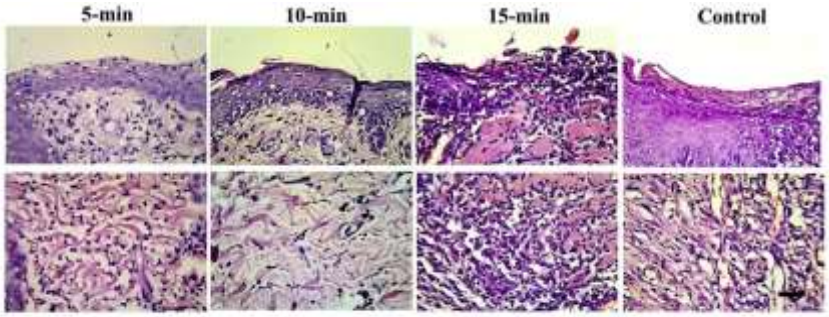


Fig. 3. Hematoxylin and eosin staining of the 5-min, 10-min, 15-min, and control groups on day 11 in the epidermis (upper picture) and dermis (lower picture) (bar = 100μm).

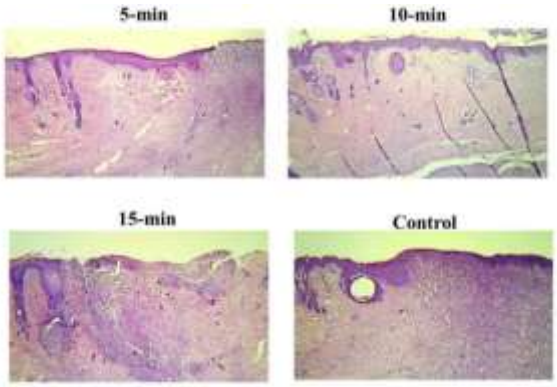


Fig. 4. The appearance of reepithelialization in the 5-min, 10-min, 15-min, and control groups on day 11 at (magnification 200×).

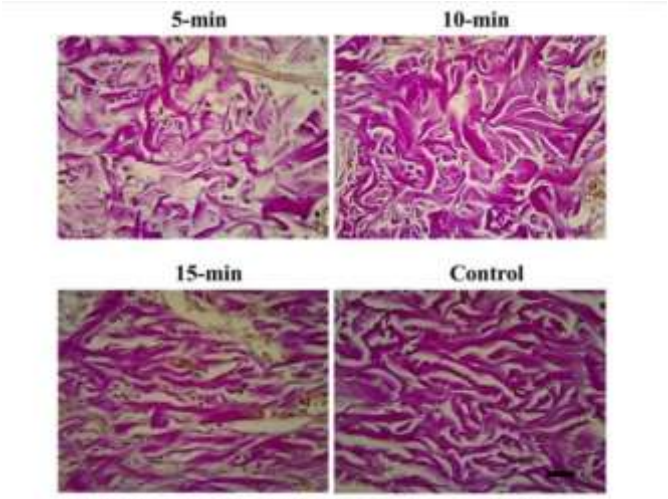


Fig. 5. Van Gieson staining in the 5-min, 10-min, 15-min and control groups on day 11 (bar = 100 μm).

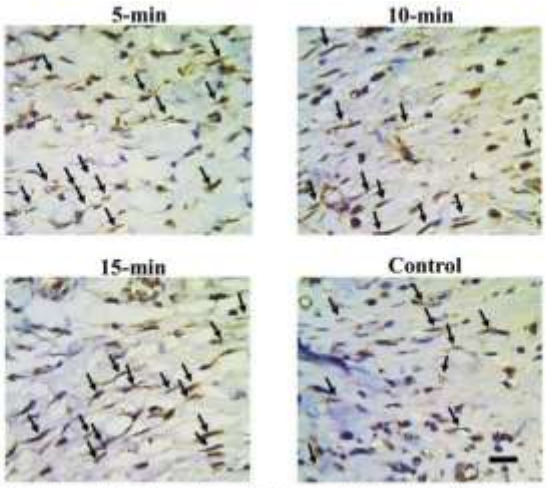


Fig. 6. MMP-9-positive cells in the dermis in the 5-min, 10-min, 15-min, and control groups on day 11 (n = 5) (bar = 100 μm). (For interpretation of the references to colour in the text, the reader is referred to the web version of this article.)

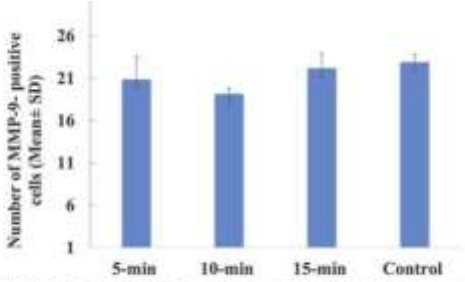
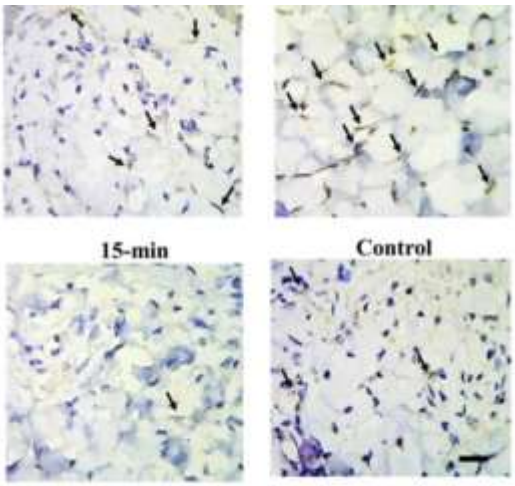
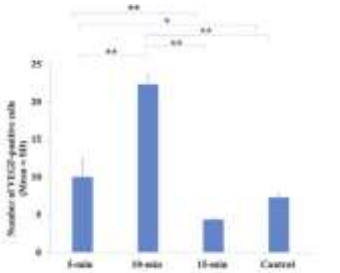


Fig. 7. Level of MMP-9-positive cells among the 5-min, 10-min, 15-min, and control groups on day 11. No significant differences were observed among the four groups.

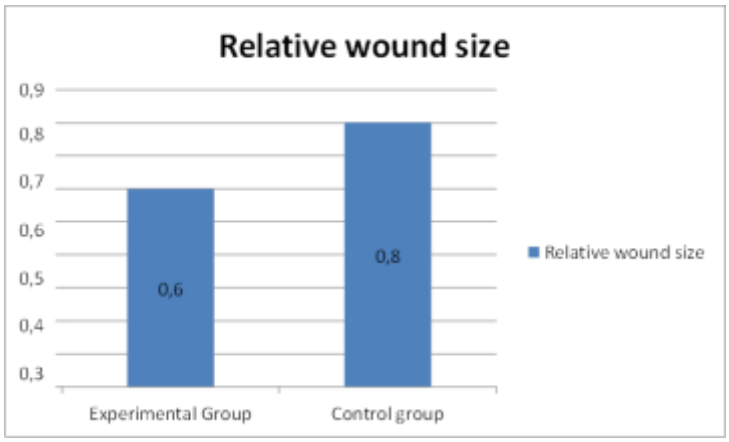




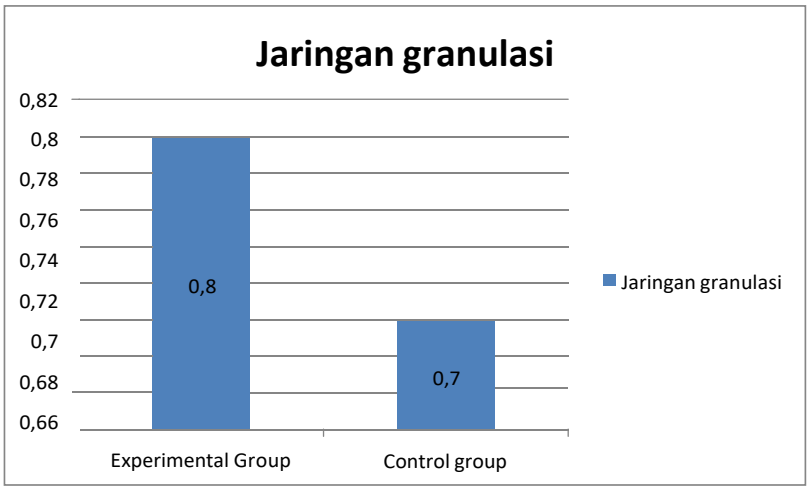
- Hasil tahun ketiga :
  1. Mengurus uji etik dan ijin penelitan pada subyek manusia
  2. Uji validitas dan reliabilitas kuesioner
  3. Mendata pasien di klinik luka dan di kelompok peduli diabetes yang akan menjadi subyek penelitian
  4. Melakukan penelitian eksperimen pada pasien dengan luka diabetes (50 pasien) dan kontrol (50 pasien) diikuti selama 4 bulan
  5. Menganalisis data ukuran luka yang diperoleh pada eksperimen
  6. Analisis jaringan jaringan granulasi, proporsi jumlah dan jenis eksudat, proporsi terowongan luka, proporsi kondisi tepi luka
  7. Artikel di jurnal internasional (accepted), buku ajar sudah cetak, seminar internasional (presented)

Hasil

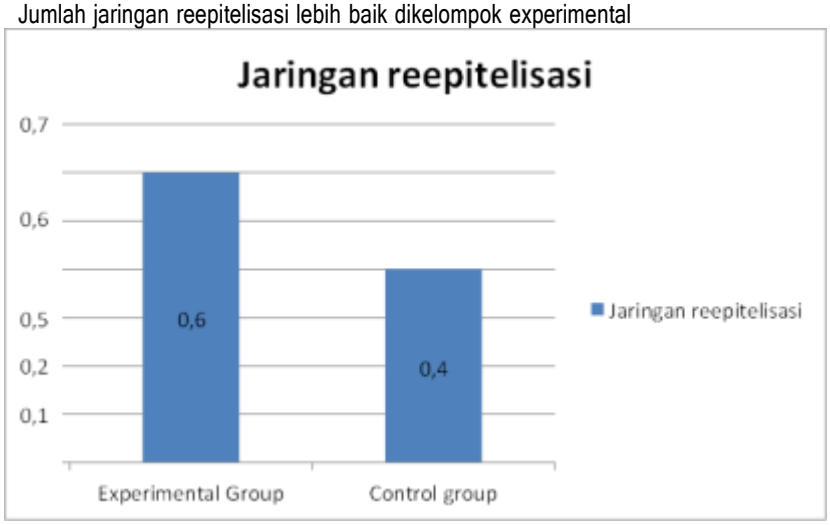
1. Ukuran luka antara kelompok experimental (aplikasi ES), dengan kelompok control (tidak dilakukan ES)



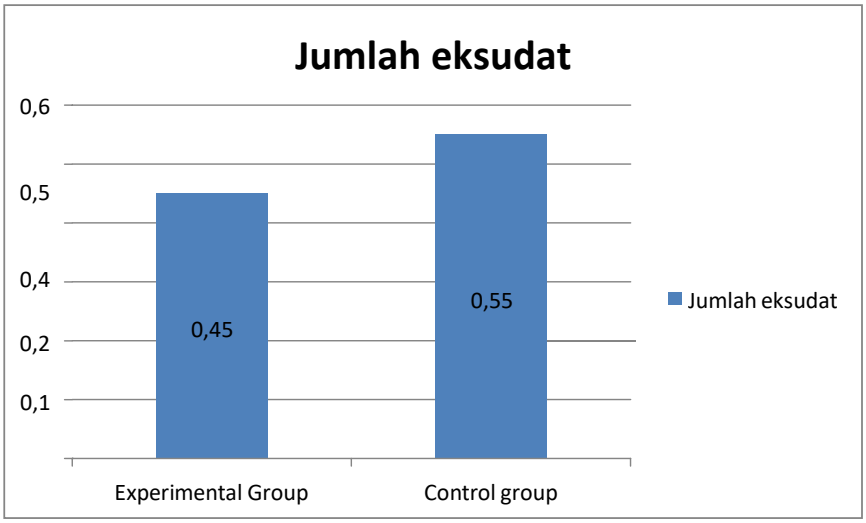
2. Tipe jaringan luka : jaringan granulasi lebih baik di kelompok experimental (aplikasi ES), dengan kelompok control (tidak dilakukan ES)



3. Jumlah jaringan reepitelisasi lebih baik dikelompok experimental



4. Jumlah eksudat



D. STATUS LUARAN: Tuliskan jenis, identitas dan status ketercapaian setiap luaran wajib dan luaran tambahan (jika ada) yang dijanjikan pada tahun pelaksanaan penelitian. Jenis luaran dapat berupa publikasi, perolehan kekayaan intelektual, hasil pengujian atau luaran lainnya yang telah dijanjikan pada proposal. Uraian status luaran harus didukung dengan bukti kemajuan ketercapaian luaran sesuai dengan luaran yang dijanjikan. Lengkapi isian jenis luaran yang dijanjikan serta mengunggah bukti dokumen ketercapaian luaran wajib dan luaran tambahan melalui Simlitabmas mengikuti format sebagaimana terlihat pada bagian isian luaran

Tahun pertama : produk alat ES, jurnal terakreditasi DIKTI (submitted), hak cipta (register), buku ajar (draft), presentasi di seminar internasional (sudah dilaksanakan), invited speaker (sudah dilaksanakan).

Tahun kedua : hasil uji coba ES pada hewan coba, jurnal terakreditasi DIKTI (published), hak cipta (granted), buku ajar (editing, presentasi di seminar internasional (sudah dilaksanakan), invited speaker (sudah dilaksanakan)

Tahun ketiga : Artikel di jurnal internasional (accepted), buku ajar sudah cetak, seminar internasional (presented), prosiding (published)

E. PERAN MITRA: Tuliskan realisasi kerjasama dan kontribusi Mitra baik in-kind maupun in-cash (jika ada). Bukti pendukung realisasi kerjasama dan realisasi kontribusi mitra dilaporkan sesuai dengan kondisi yang sebenarnya. Bukti dokumen realisasi kerjasama dengan Mitra diunggah melalui Simlitabmas mengikuti format sebagaimana terlihat pada bagian isian mitra

Kerjasama dengan mitra berjalan dengan baik. Peran mitra disini adalah memberikan informasi terkait pasien yang akan diberikan alat ES. Mitra berperan dengan baik pada saat proses penelitian, disini mitra juga memberikan bantuan berupa in-kind yaitu menyediakan alat-alat yang digunakan untuk perawatan luka serta membantu menyiapkan kondisi luka untuk dikaji.

F. KENDALA PELAKSANAAN PENELITIAN: Tuliskan kesulitan atau hambatan yang dihadapi selama melakukan penelitian dan mencapai luaran yang dijanjikan, termasuk penjelasan jika pelaksanaan penelitian dan luaran penelitian tidak sesuai dengan yang direncanakan atau dijanjikan.

Kendala :

1. Pasien terkadang tidak datang diwaktu yang telah ditentukan
2. Pasien berhenti menjadi respondent ditengah penelitian

G. RENCANA TINDAK LANJUT PENELITIAN: Tuliskan dan uraikan rencana tindaklanjut penelitian selanjutnya dengan melihat hasil penelitian yang telah diperoleh. Jika ada target yang belum diselesaikan pada akhir tahun pelaksanaan penelitian, pada bagian ini dapat dituliskan rencana penyelesaian target yang belum tercapai tersebut.

Hasil penelitian menunjukan bahwa alat ES dapat mempercepat penyembuhan luka pada hewan dan manusia, hal yang perlu dilakukan lagi kedepannya adalah menguji alat dalam skala besar yaitu tingkat komunitas (berbasis populasi).

H. DAFTAR PUSTAKA: Penyusunan Daftar Pustaka berdasarkan sistem nomor sesuai dengan urutan pengutipan. Hanya pustaka yang disitasi pada laporan akhir yang dicantumkan dalam Daftar Pustaka.

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Dokumen pendukung luaran Wajib #1

Luaran dijanjikan: Dokumentasi hasil uji coba produk

Target: Ada
Dicapai: Tersedia

Dokumen wajib diunggah:
1. Dokumentasi (foto) Pengujian Produk
2. Dokumen Deskripsi dan Spesifikasi Produk
3. Dokumen Hasil Uji Coba Produk

Dokumen sudah diunggah:
1. Dokumen Deskripsi dan Spesifikasi Produk
2. Dokumen Hasil Uji Coba Produk
3. Dokumentasi (foto) Pengujian Produk

Dokumen belum diunggah:
-

Nama Produk: Stimulasi Elektris
Tgl. Pengujian: 1 Juni 2019
Link Dokumentasi: https://www.youtube.com/watch?v=0lBmb7uBKaE

DESKRIPSI PRODUK ALAT STIMULASI ELEKTRIS UNTUK PERAWATAN LUKA DIABETES

Invensi bertujuan untuk menyediakan alat stimulasi elektrik. Alat stimulasi elektrik terdiri dari dua bagian, yaitu pembangkit pulsa elektrik dan pembangkit tegangan DC variabel. Pembangkit pulsa elektrik merupakan rangkaian elektronik yang dapat membangkitkan sinyal elektrik yang berupa gelombang persegi yang selanjutnya disebut dengan pulsa elektrik. Pulsa elektrik dibangkitkan dengan menggunakan rangkaian multivibrator astabil. Rangkaian multivibrator dapat menghasilkan pulsa elektrik yang dapat diatur frekuensi dan lebar pulsanya. Pembangkit tegangan DC variabel merupakan rangkaian elektronik yang dibuat untuk menghasilkan tegangan DC yang dapat divariasi nilai amplitudonya dari 0 volt sampai 60 volt. Pembangkit tegangan DC variabel dibuat menggunakan rangkaian pembagi tegangan. Sinyal listrik keluaran dari alat ini dihubungkan dengan penderita melalui sepasang elektroda. Sepasang elektroda direkatkan pada bagian kulit yang dikehendaki, sehingga akan terjadi aliran arus listrik ke dalam jaringan tubuh.

Komponen yang dibutuhkan pada pembuatan alat ini adalah yaitu elektroda dan catu daya.Bagian elektroda berfungsi sebagai penyalur arus listrik ke bagian tubuh yang dikehendaki. Elektroda dibuat sepasang dari bahan logam tahan korosi yang dapat dengan mudah ditempel pada bagian tubuh. Catu daya berfungsi sebagai penyuplai arus listrik pada kedua elektroda. Arus listrik yang dihasilkan oleh catu daya berupa pulsa listrik yang berbentuk gelombang kotak dengan amplitudo dan frekuensi tertentu yang dapat

divariasi. Variasi ini digunakan untuk mendapatkan nilai optimum terhadap proses penyembuhan luka.

Invensi ini bertujuan untuk menyediakan alat perawatan luka dengan prinsip stimulasi elektris yang memiliki karakteristik voltase sampai dengan 60 volt.

Uraian singkat Gambar

Gambar 1. Rangkaian Multivibrator astabil sebagai pembangkit pulsa elektrik

Gambar 2. Rangkaian pembangkit tegangan dc

Gambar 3. Susunan Rangkaian stimulasi elektrik

Uraian Lengkap Invensi

Invensi ini bertujuan untuk menyediakan alat stimulasi elektris. Alat ini dibuat dengan memanfaatkan komponen-komponen yang mudah diperoleh secara lokal sehingga mudah untuk diproduksi massal. Selain itu, pengoperasian alat ini juga sangat mudah.

Pembuatan stimulasi elektrik dilakukan dalam beberapa langkah, yaitu: a) membuat rangkaian pembangkit pulsa elektrik dengan multivibrator astabil (Gambar 1). Pembangkit pulsa dibuat dengan frekuensi dan lebar pulsa yang dapat diatur. b)memasang saklar putar untuk menentukan pilihan frekuensi dan lebar pulsa sesuai yang dibutuhkan. c)membuat pembangkit tegangan DC variabel. Pembangkit tegangan DC variabel dibuat untuk memvariasi amplitudo pulsa elektrik (Gambar 2). Rangkaian dibuat menggunakan konsep pelipat tegangan. d)memasang potensio untuk mengatur tinggi rendahnya amplitudo pulsa elektrik. Variasi tegangan dibuat menggunakan konsep pembagi tegangan, sehingga amplitudo pulsa dapat divariasi dari 0

sampai 60 volt e)menghubungkan rangkaian pembangkit pulsa dan pembangkit tegangan DC variabel menjadi satu rangkaian. f)memasang lampu indikator untuk menunjukkan range frekuensi dan lebar pulsa yang sedang digunakan. g)memasang voltmeter pada bagian keluaran rangkaian untuk melihat tegangan atau amplitudo elektrik. h)memasang ampermeter pada jalur keluaran untuk memantau arus listrik yang diinjeksikan ke tubuh (Gambar 3). i) memasang kabel penghubung yang dilengkapi dengan sepasang elektroda. Elektroda dibuat dari logam yang tidak korosi. Elektroda digunakan untuk menyalurkan arus listrik ke dalam tubuh. j)menguji sinyal keluaran stimulasi elektrik pada frekuensi dan lebar pulsa tertentu serta variasi tegangan dari 0 sampai 60 volt. k) melakukan pengemasan dalam sebuah bok untuk memudahkan penggunaan dan penyimpanan.

Stimulasi elektrik dibuat menggunakan komponen-komponen yang mudah ditemukan. Rangkaian pembangkit pulsa terdiri dari beberapa komponen, yaitu: IC NE555, 2 buah kapasitor dan 2 buah variabel resistor. Sementara pembangkit tegangan DC variabel terdiri dari transformator step down 1 ampere, 2 buah dioda bridge 1 ampere, 5 buah dioda daya 1N4005, 5 buah kapasitor non polar 100 nF dan 2 buah kapasitor polar masing-masing 1000 μF/16 V dan 100 μF/200 V. 5 buah dioda daya 1N4005 dan 5 buah kapasitor non polar digunakan untuk pelipat tegangan, sehingga dihasilkan tegangan sekitar 100 volt. Variasi tegangan dibuat menggunakan sebuah transistor mosfet IRF740 dan sebuah variabel resistor. Variabel resistor ini digunakan untuk memvariasikan tegangan DC dari 0 sampai 60 volt.

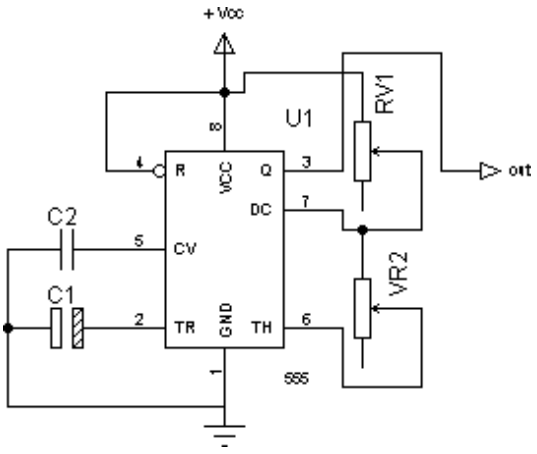
Dalam alat ini, IC NE555 sebagai otak dari rangkaian multivibrator bekerja secara bersama sama dengan komponen pendukung lainnya, yaitu resistor dan kapasitor. IC NE555 terdiri dari 8 pin. Pin 1 dan 8 sebagai input catu daya, yaitu jalur untuk memberikan tegangan masukan pada IC. Pin 2 sebagai trigger dan pin 5 untuk kontrol tegangan dihububgkan dengan kapasitor. Kapasitor akan terisi muatan listrik dan akan melepaskan muatannya kembali pada batas tegangan tertentu. Tegangan yang dilepaskan akan mentrigger IC untuk aktif. Kecepatan pengisian (charger)dan pelepasan muatan (discharger) pada kapasitor ditentukan oleh resistor yang terpasang melalui pin 6 dan 7. Pin 3 sebagai jalur output akan menghasilkan arus listrik yang terputus putus membentuk pulsa. Banyak sedikitnya jumlah pulsa dalam 1 detik (frekuensi) ditentukan oleh nilai resistor dan kapasitor.

Pemantauan tegangan dan arus keluaran alat stimulasi elektrik menggunakan voltmeter dan ampermeter digital. Kedua alat dipasang pada bagian keluaran arus listrik. Pulsa elektrik keluaran dari alat dihubungkan dengan tubuh melalui kabel penghubung yang sudah dipasang elektroda.

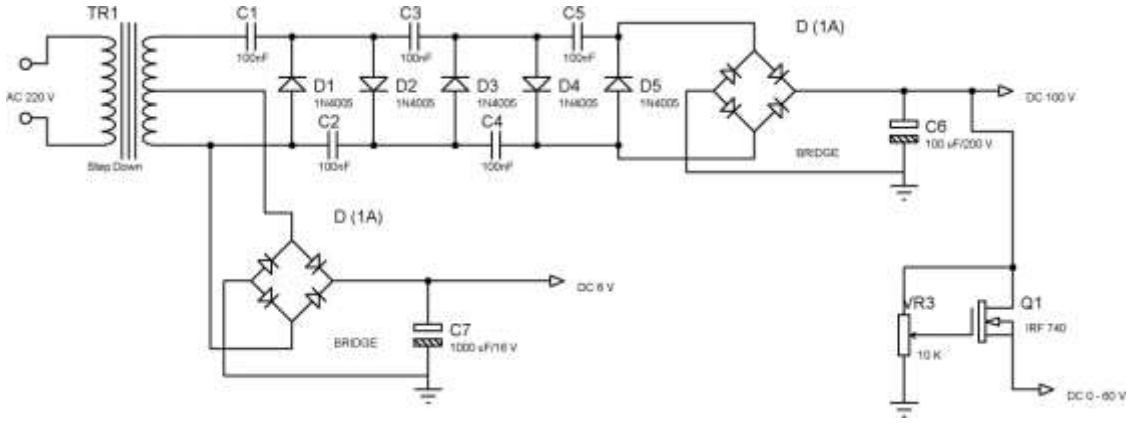
Pengoperasian alat stimulasi elektrik sangat sederhana. Langkah-langkah yang harus dilakukan adalah sebagai berikut: a)memasang sepasang elektroda di sekitar luka. b)menghubungkan konektor elektroda pada alat stimulasi elektrik. c)memastikan semua pengatur berada pada posisi minimum (posisi 0). d)menghubungkan kabel power ke listrik PLN. e)menghidupkan alat stimulasi elektrik melalui tombol power. f)menentukan frekuensi dan lebar pulsa menggunakan pengatur yang tersedia. g) mengatur tegangan keluaran stimulasi elektrik sesuai

dengan ketentuan menggunakan tombol pengatur tegangan dan melihat nilai tegangan dan arus pada voltmeter dan ampermeter.

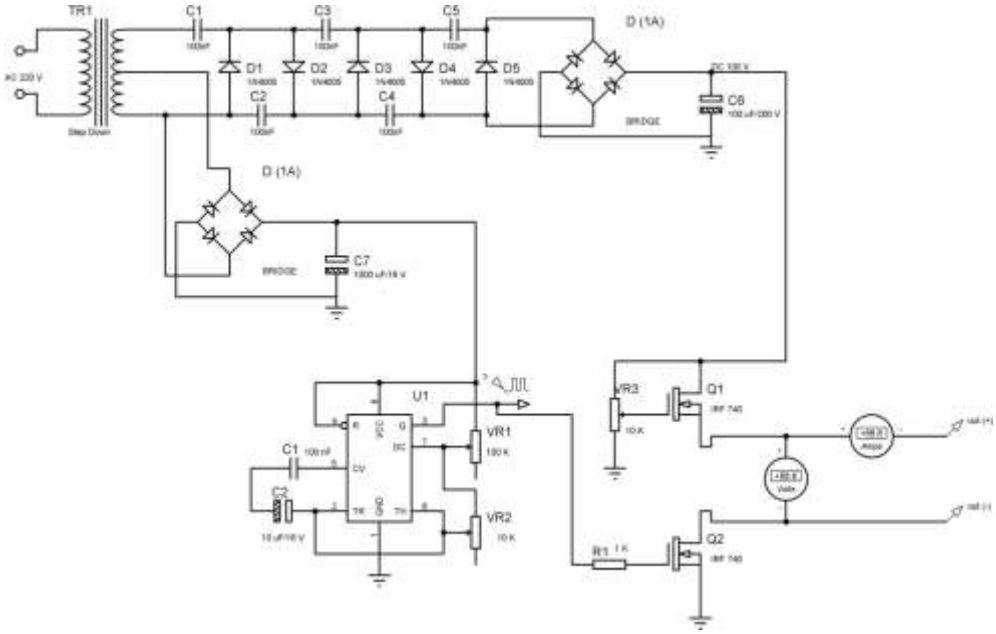
Prosedur mengakhiri penggunaan alat stimulasi elektrik juga sangat sederhana. Berikut adalah langkah-langkahnya, a)menurunkan tegangan sampai pada nilai 0 volt menggunakan tombol pengatur tegangan. b)mematikan alat melalui tombol power. c)mencabut kabel power dari listrik PLN. d)melepaskan elektroda dari tubuh dan melepaskan konektor dari alat stimulasi elektrik.



Gambar 1



Gambar 2



Gambar 3

Alat yang sudah jadi

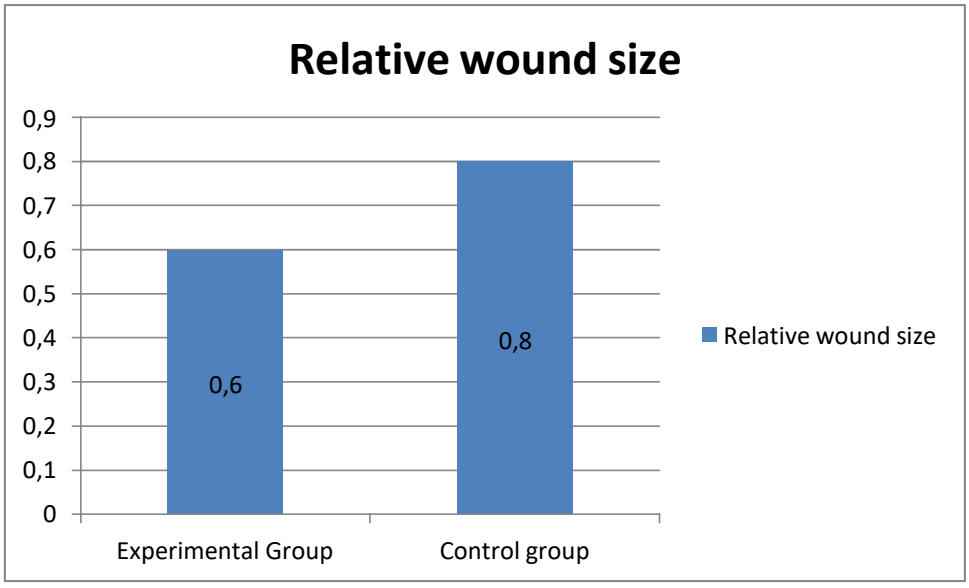
Dokumen Hasil Uji Coba

1. Semua pasien tidak menyatakan ada rasa nyeri saat aplikasi ES
2. Semua pasien tidak ada rasa terbakar saat aplikasi ES
3. Semua pasien menyatakan tidak ada rasa tidak nyaman saat aplikasi ES
4. Samples

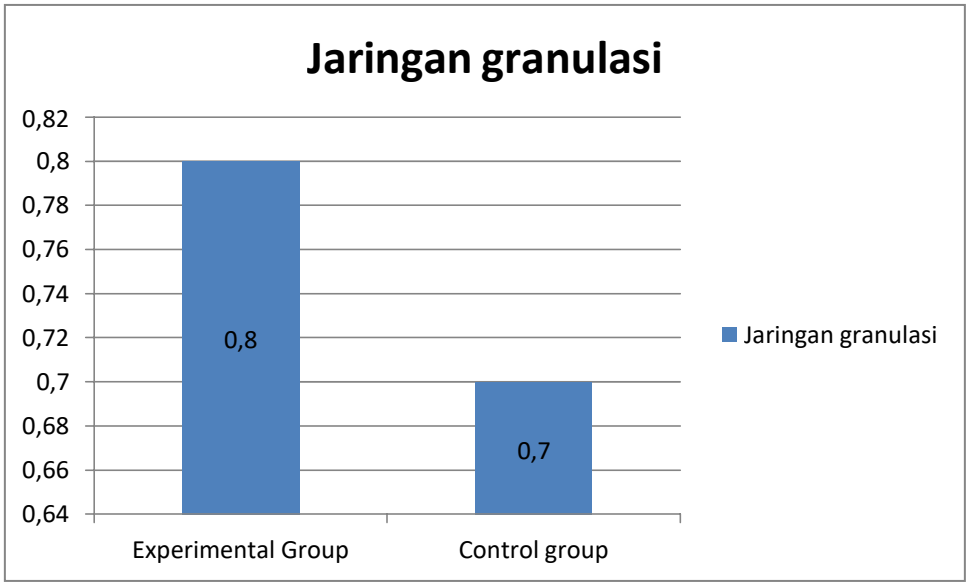
Jenis kelamin	Experiment	Control
Laki-laki	30	28
Perempuan	35	37

Hasil ujicoba ES pada penyembuhan luka

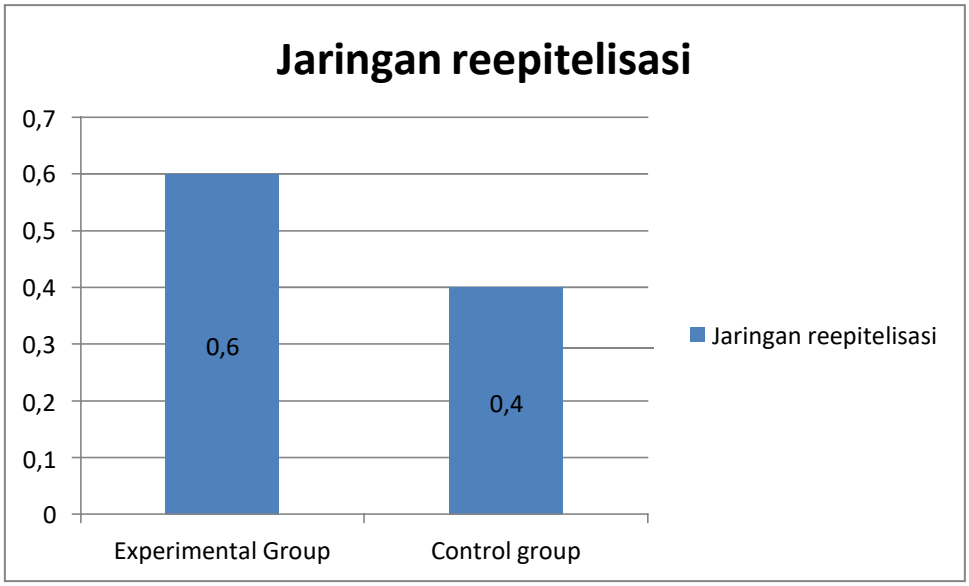
1. Ukuran luka antara kelompok experimental (aplikasi ES), dengan kelompok control (tidak dilakukan ES)



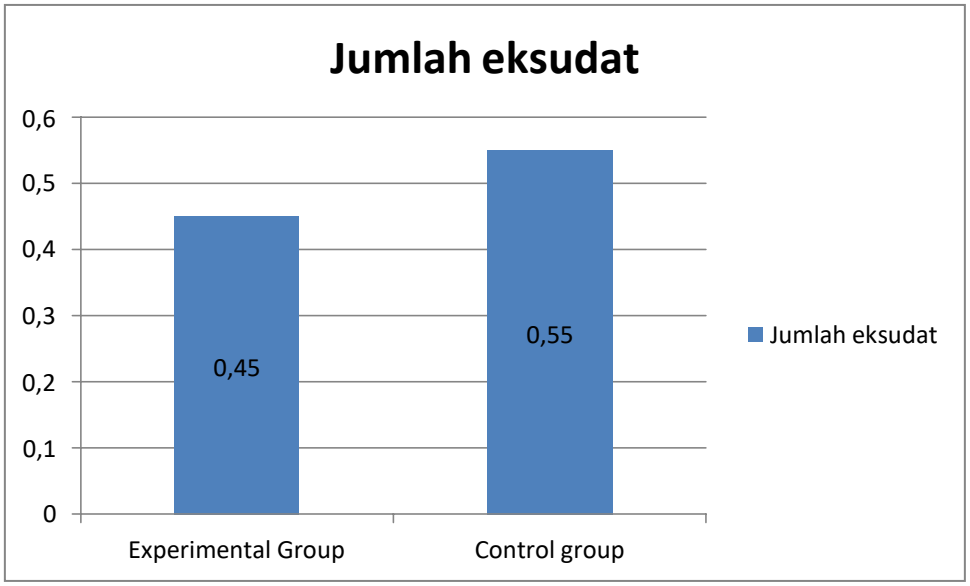
2. Tipe jaringan luka : jaringan granulasi lebih baik di kelompok experimental (aplikasi ES), dengan kelompok control (tidak dilakukan ES)

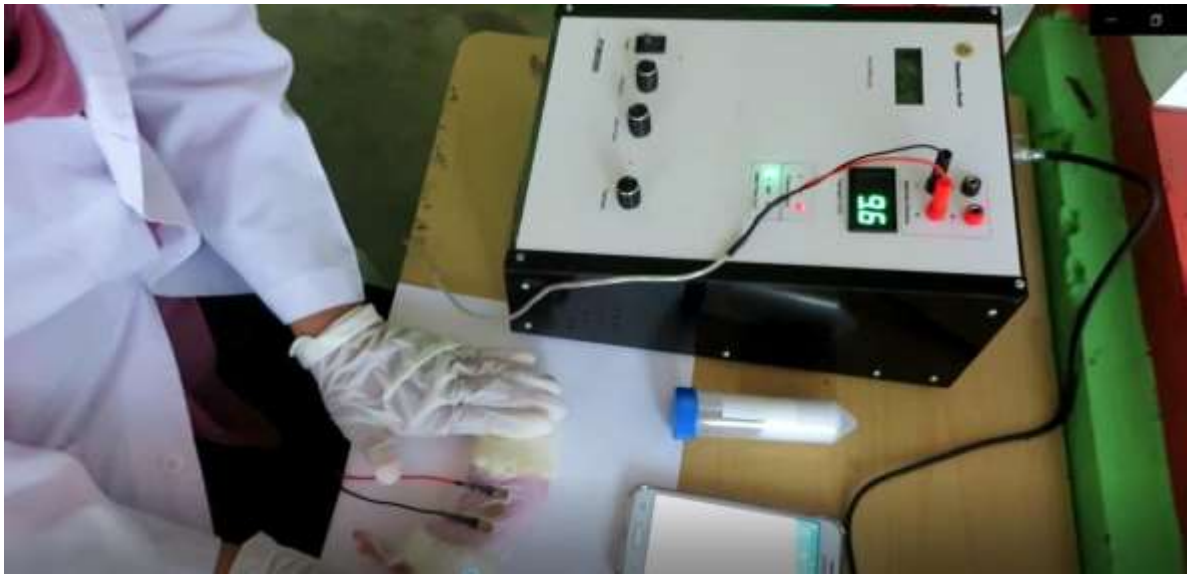


3. Jumlah jaringan reepitelisasi lebih baik dikelompok experimental



4. Jumlah eksudat


Jumlah eksudat
0,6
0,5
0,4
0,3
0,2
0,1
0
0,45
0,55
Experimental Group
Control group
Jumlah eksudat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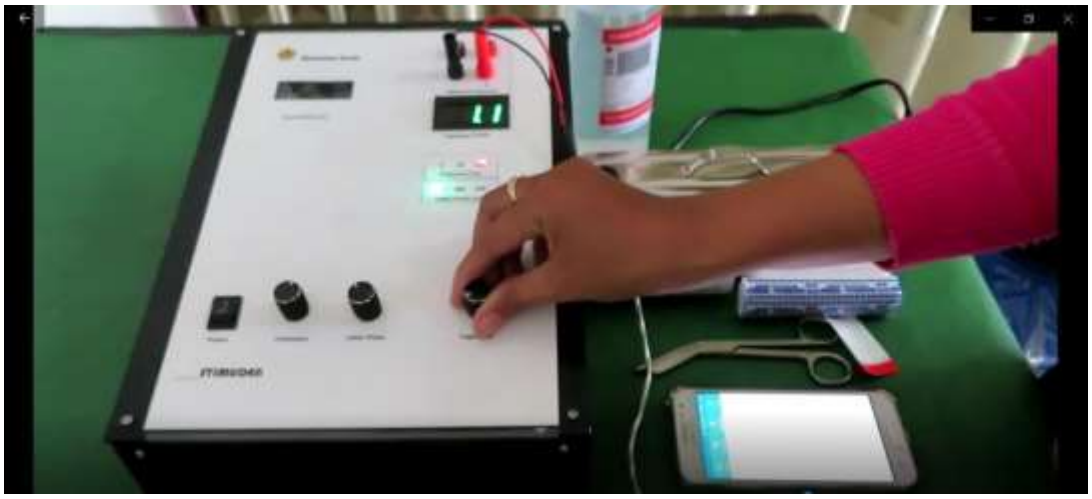

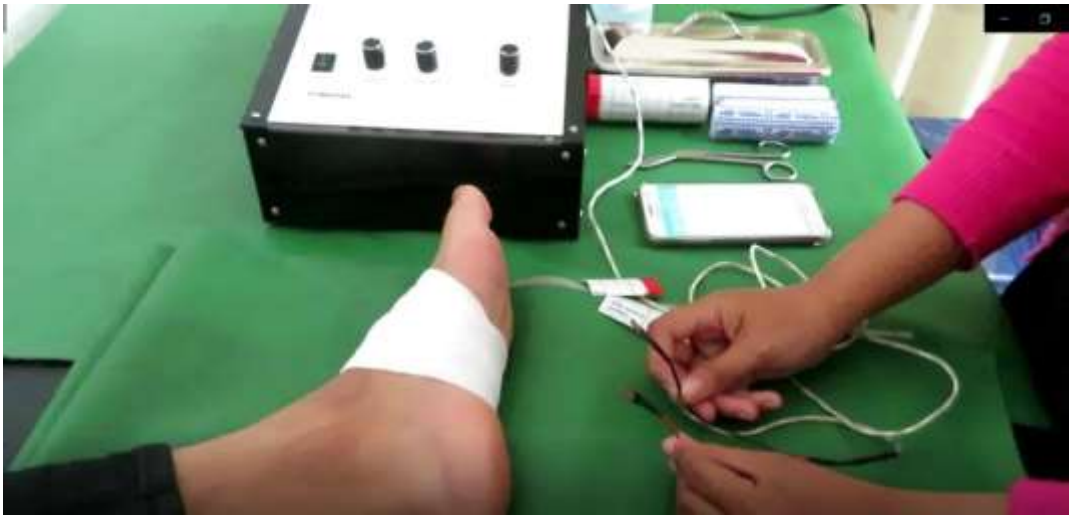

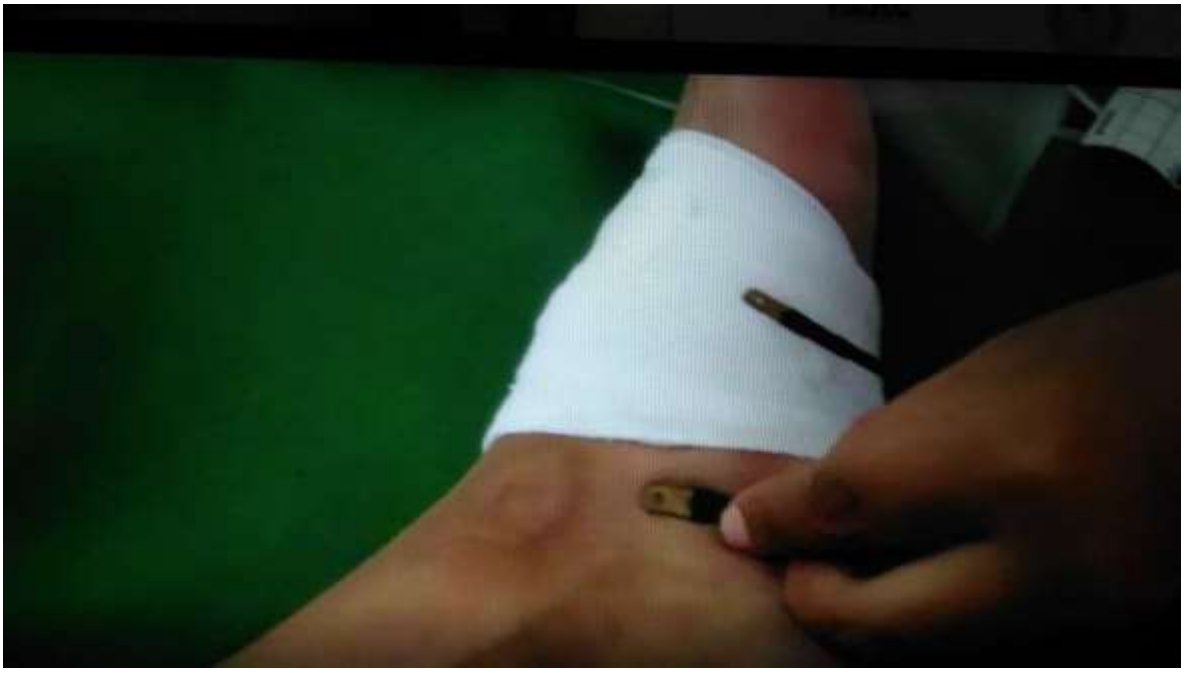

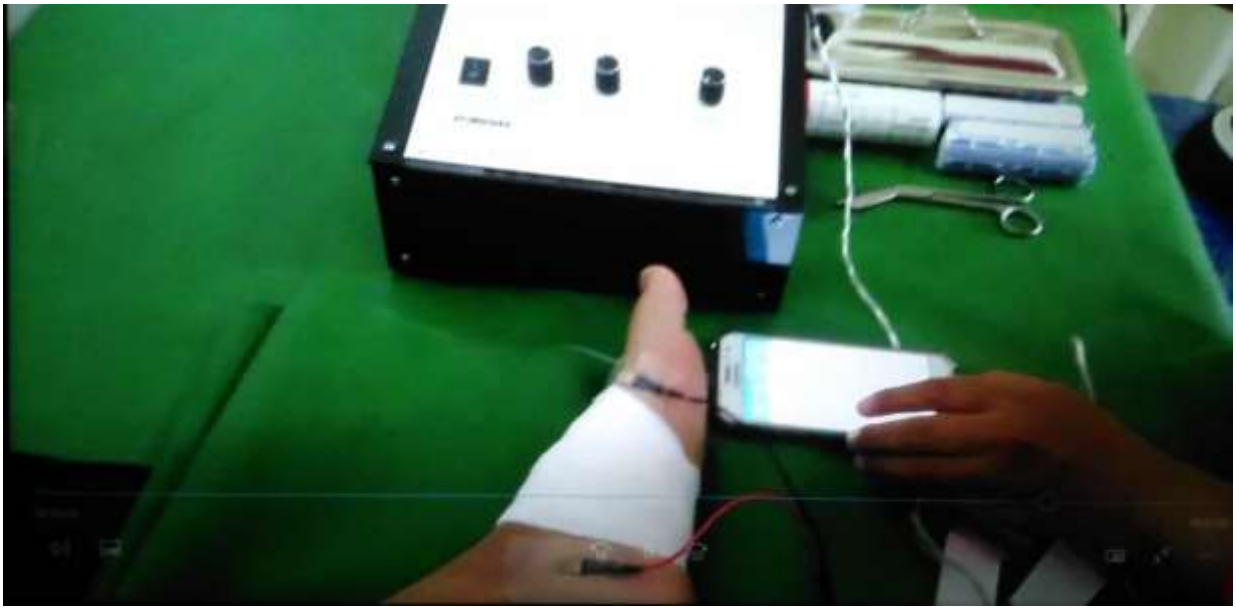

Dokumen pendukung luaran Tambahan #1

Luaran dijanjikan: Publikasi Ilmiah Jurnal Internasional

Target: accepted/published
Dicapai: Published

Dokumen wajib diunggah:
1.

Dokumen sudah diunggah:
1. Artikel yang terbit

Dokumen belum diunggah:
-

Nama jurnal: Wound Medicine
Peran penulis: first author | EISSN: 2213-9095/2213-9109
Nama Lembaga Pengindek: Scopus
URL jurnal: https://www.sciencedirect.com/science/article/abs/pii/S2213909518300703
Judul artikel: The effect of short duration of electrical stimulation on wound healing in acute wound in a rat model
Tahun: 2019 | Volume: 24 | Nomor: 1
Halaman awal: 36 | akhir: 44
URL artikel: https://www.sciencedirect.com/science/article/abs/pii/S2213909518300703

DOI: https://doi.org/10.1016/j.wndm.2019.02.003

Wound Medicine 24 (2019) 36–44

Contents lists available at ScienceDirect

Wound Medicine

journal homepage: www.elsevier.com/locate/wndm

Original research article

The effect of short duration of electrical stimulation on wound healing in acute wound in a rat model

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ARTICLE INFO

Keywords:
Angiogenesis
Electrical stimulation
MMP-9
Reepithelialization
Wound healing

ABSTRACT

Background: Prolonged application of electrical stimulation (ES) will cause skin discomfort and burns, and therefore may be harmful in the elderly population with morbid conditions. Therefore, it is needed to apply ES in a short duration. However, currently, no studies have been conducted that investigated the effect of short duration of ES on wound healing. This study purpose was to investigate the effect of short duration of ES on wound healing of acute wounds in rats.

Methods: In this study, a wound was created on the back of rats. Rats were assigned to one of the following 4 groups; ES treatment 5 minutes (5-min group), ES treatment 10 minutes group (10-min group), ES treatment 15 minutes (15-min group), and a control group (film dressing). ES (20 Hz, 320 μs, 50 μA) was delivered for 11 days.

Results: From day 4 onward, wound sizes were significantly lower in the 10-min group when compared to the 15-min group, and control group on day 10 and 11. In the 10-min group, inflammation was the lowest when compared to other groups, while the intensity of fibroblast was significantly higher than in the 15-min and control groups. Reepithelialization was most advanced in the 10-min group compared with other groups. The number of MMP-9 positive cells was not significantly different among groups, whereas the number of VEGF-positive cells was significantly higher in the 10-min group when compared with other groups.

Conclusion: ES application for 10 minutes significantly reduced inflammation, improved reepithelialization and angiogenesis when compared to shorter and longer applications. ES for 10 minutes also significantly improved wound healing when compared to the use of modern dressing alone. Therefore, it is recommended to apply ES for 10 minutes a day to improve wound healing.

1. Background

The presence of wounds will cause an increase in costs for both patients and the health economy [1]. Unhealed wound also will have a high impact on depression, a low quality of life (QOL), and even mortality [1]. In a previous study, it was estimated that 6.5 million patients in the USA suffer from unhealed wounds and that more than US $25 billion is spent to treat such wounds [2]. In addition, a study in the UK showed that the cost to treat wounds was around was roughly 3% of the total expenditure on healthcare, or around US$ 4.6 billion per year [2]. The prevalence of wounds might increase in the aging population as a main sufferer of wounds increases worldwide [3]. Considering the impact of wounds, many clinicians and wound care experts aim to identify novel therapies for improving wound healing.

Many therapies have been used to treat wounds, such as modern dressing [4], topical therapies [5], ultrasound etc [6]. However, wounds are still a huge problem both economically and clinically. Recently, electrical stimulation (ES) has gained significant attention for many purposes, including improving blood flow and reducing pain [7–9]. ES is a therapy that delivers a low electrical current through an electrode to the target tissue. The epidermis of intact skin has electrical potential, resulting from the uneven distribution of sodium ions, thereby causing a potential difference at the range of 10–60 mV [10]. Damaged to the epidermis will cause a change in the electrical current of the body, resulting in an electrical field [11]. During wound healing, this electrical field will improve the migration of epithelial cells [12].

Previous studies showed that ES has beneficial effects on wound healing [13–21]. It has been shown that ES accelerated the healing of

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https://doi.org/10.1016/j.wndm.2019.02.003
Received 29 December 2018; Accepted 14 February 2019
Available online 21 February 2019

acute wounds [16], diabetic ulcers [20,21], pressure ulcers [18], and venous ulcers [22]. However, most previous studies have focused on the intensity (frequency) of application [16,19,22–26]. In addition, ES has been applied at the range of 30 minutes – 8 hours a day [17,22,24–26]. However, it has been shown that prolonged application of ES can cause discomfort and even skin burns [27,28]. The effect of skin burns and discomfort is harmful to patients, especially the elderly. Moreover, most patients with unhealed wounds frequently also suffer from other disease and morbid conditions, and therefore long-term application of ES may be harmful to the body. Therefore, it is needed to apply ES for a short-term duration in one day. However, currently, no studies have been conducted that investigated the effect of short duration of ES on wound healing. Therefore, in this study, we aimed to investigate the effect of short duration of ES on wound healing.

In a previous study, it was shown that the most important phase during wound healing is proliferation phase [16]. Angiogenesis is a critical component in the proliferation phase of wound healing [16]. In addition, MMP-9 expression is one of most important factors during the process of wound healing [29]. Previously, it has been showed that the prolonged and excessive production of MMP-9 will lead to delayed wound healing, whereas low levels or no MMP-9 expression were associated with healed wounds [30]. High MMP-9 expression also correlated with the deterioration of wounds into chronic wounds [29]. Currently, the role of ES on MMP-9 expression is still unclear. Therefore, in this study we investigated MMP-9 and angiogenesis following the treatment with short duration of ES.

2. Methods

In this study, male Wistar rats (180–200 g; 12–14 weeks of age) were used. Rats were obtained from the Pharmaceutical Laboratory Animal, Universitas Muhammadiyah Purwokerto, and had access to food and water ad libitum. Before wounding, animals were acclimatized for seven days. This study protocol was approved by the ethical committee, Faculty of Medicine, Jenderal Soedirman University, Purwokerto (1208/KEPK/III/2017)

2.1. Procedure

To create a wound, rat hair was removed by shaving. Removal of hair was conducted 1 day before the wounding procedure. The wounding procedure was based on previous studies [31]. In brief, one full-thickness wound, 1 cm long, was created on the back of rats. After wounding, the wound was cleansed with NaCl, then the wound was covered with modern dressing (film dressing) (BSN medical, Hamburg, Germany). Next, ES was applied to the left and right side of the wound. The application of ES was based on our previous studies [20,21]. In brief, the electrodes of the ES device were attached to the right and left side of the wound areas. ES was applied for 5 minutes (5-min group), 10 minutes (10-min group), 15 minutes (15 min-group) for 11 eleven days (20 Hz, 320 μs, 50 μA). Rats in the control group received modern dressing (film dressing), and did not receive ES. After finishing the application of ES, wounds were covered with gauze to fix the position of the dressing. All rats survived and lived until the end of the study.

2.2. Wound size

From day 0 to day 11, the sizes of the wounds were measured by ImageJ software as based on previous studies [32]. Relative wound size were calculated based on a previous study [32]. The formula used was as follows: Relative wound size = size at day n – size at day 0)/(size at day 0) [32]. Rats were sacrificed and skin tissue was harvested on day 11 post wounding.

2.3. Histological examination

The wound tissue and normal skin surrounding of wound were obtained for histological analysis. After sacrificing the rats, a sample of skin was immersed in 10% formalin. The skin tissue was then dehydrated in a series of ethanol and xylene. The tissue samples were finally embedded in paraffin. Next, skin tissue was cut at 4 μm thickness. The sectioned skin was then deparaffinized and rehydrated in xylene and ethanol. Subsequently, the sectioned skin was stained with Hematoxyllin and eosin staining and Van Giesson staining, and sections were observed under a light microscope.

2.4. Immunohistochemistry

The preparation of the skin sections was similar as described above. For immunohistochemistry, the method used in this study was based on the approach used in a previous study [31]. Paraffin sections were mounted onto Polylysine-coated slides. To inactivate the activity of endogenous peroxidase, sections were incubated in 3% H_20_2 for 30 min at room temperature. For immunostaining of MMP-9, antigen retrieval was performed by immersion in citrate buffer (pH 6.0) for 15 min and for immunostaining with VEGF, antigen retrieval was carried out by autoclaving the slides in Tris EDTA pH 9 for 15 min. Sections were then incubated with primary antibodies. The primary antibody used in this study included a mouse anti- rat MMP-9 (Abcam, Cambridge, UK) at 1:100 or a mouse anti-rat VEGF antibody (Abcam, Cambridge, UK) at 1:100. The sections were washed with PBS and incubated with a biotin-conjugated secondary antibody (1:100). Streptavidin-peroxidase was used to visualize the staining, and diaminobenzidine substrate as a chromogenic agent (Sigma Aldrich Co, St. Louis, USA). Lastly, hematoxylin was used as a counterstaining agent. The sections were observed under a light microscope (Olympus, Tokyo, Japan) and images were taken. MMP-9-positive cells and VEGF-positive cells were calculated by counting the number of positive cells in eight randomly selected fields using a magnification of 400 X.

2.5. Statistical analysis

The analysis was performed using SPSS version 20 software (IBM Corp., Armonk, NY, USA). The data of wound size was presented as the mean ± standard deviation. Wound size, intensity of inflammation, and the level of fibroblasts among the four groups were assessed by the Kruskal Wallis test, followed by the Man-Whitney U test. Moreover, data regarding MMP-9-positive cells and VEGF-positive cells were analyzed by the ANOVA test, followed by Tukey's test. $P < 0.05$ was considered significant.

3. Result

3.1. Wound size

The macroscopic appearance of each wound is presented in Fig. 1. On day 0 to day 1, the appearance of the wound was similar between groups. On day 1 the necrotic tissue started to appear in the control group, while in other groups, this was not observed. On day 5, the necrotic tissue in the control group was thicker when compared to the other groups. On day 7, the necrotic tissue was still thick in the 15-min group and the control group, while in the 5-min and 10-min group, the necrotic tissue was reduced when compared with other groups. In addition, the wound size in the 10-min and 5-min groups were smaller when compared to that of other groups. When comparing the control group and the 15-min group, the wound size in the 15-min group was larger when compared to the control group. On day 11, the necrotic tissue disappeared in the 10-min group and the wound was almost healed. The wound size in the 5-min group was almost similar to that in the 10-min group, however, wounds in the 5-min group were still

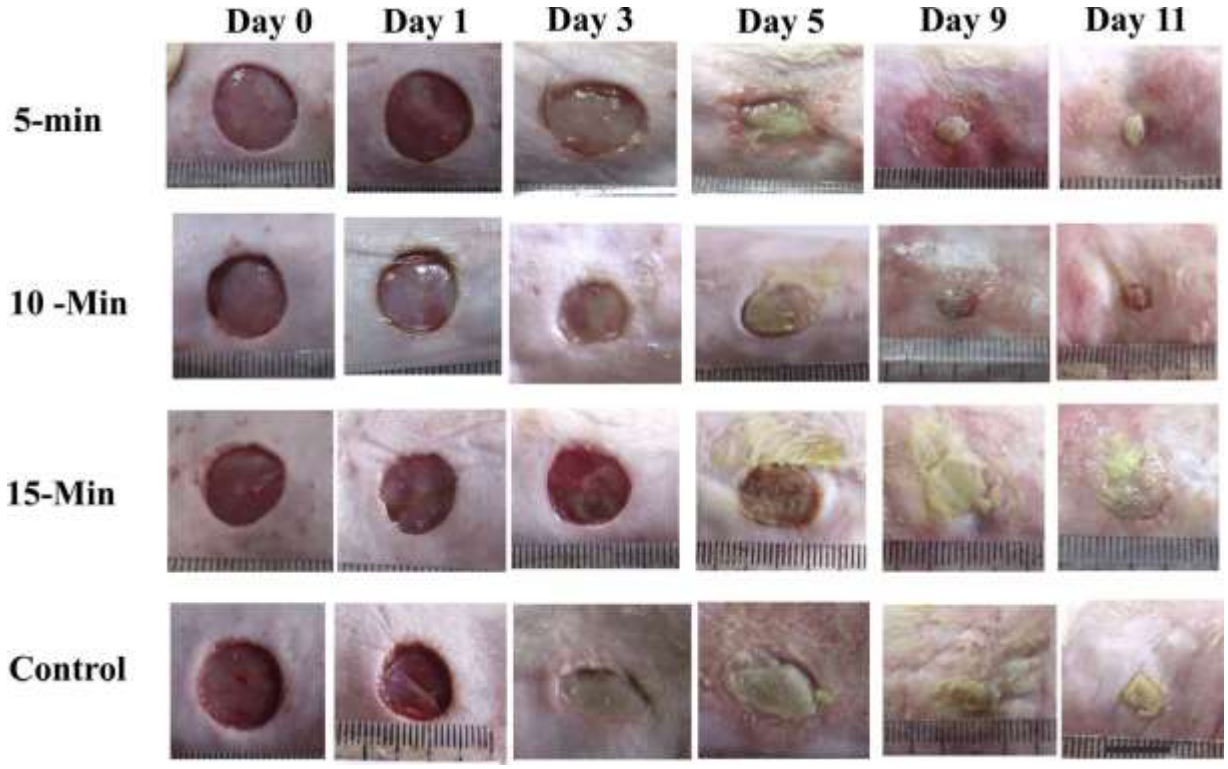

Fig. 1. Appearance of wounds in the 5-min group, 10-min group, 15-min group, and the control group (bar indicates 1 cm). Wound beds on day 11 in the 5-min, 15-min, and control groups were fully covered by necrotic tissue.

covered with necrotic tissue. In the 15 min-group and the control group, wounds were still larger compared to the 5-min and 10-min groups.

The mean wound sizes and the differences between wound sizes per group are presented in Table 1 and Fig. 2. In the 5-min group, there was significant difference in wound size between 5-min duration and 15-min duration during the late inflammation phase (P = 0.043), and early proliferative phase (day 7, P = 0.043; day 8, P = 0.043, and day 9, P = 0.02). However, in the 5-min group, the data was not significantly different compared with other groups on day 10 to day 11. In the 10-min group, the wounds gradually decreased over the healing period. From day 4 onward, the wound size in the 10-min group was significantly smaller when compared with the 15-min group (day 4 = 0.021, day 5, P = 0.021, day 6, P = 0.021, day 7, P = 0.043, day 8, P = 0.043, day 9, P = 0.021, day 10, P = 0.020, day 11, P = 0.021). From day 10–11, wounds in the 10-min group was also significantly smaller compared with control group (day 10, P = 0.021, day 11, P = 0.021). In the control group, the wound size was significantly smaller when compared with the 15-min group on day 8 and 9 (day 8, P = 0.029, day 9, P = 0.043).

Table 1
The ratio of the wound size and initial size per group on day 0.

Days	5-min	10-min	15-min	Control
0	1.00 ± 0.00	1.00 ± 0.00	1.00 ± 0.00	1.00 ± 0.00
1	0.93 ± 0.11	0.89 ± 0.16	0.92 ± 0.13	0.91 ± 0.05
2	0.88 ± 0.10	0.83 ± 0.24	0.74 ± 0.20	0.84 ± 0.04
3	0.83 ± 0.00	0.69 ± 0.10	0.83 ± 0.22	0.68 ± 0.03
4	0.71 ± 0.18	0.63 ± .08*	0.93 ± 0.21	0.66 ± 0.05
5	0.66 ± 0.04*	0.61 ± 0.05*	0.85 ± 0.15	0.67 ± 0.01
6	0.66 ± 0.30	0.56 ± 0.03*	0.82 ± 0.14	0.60 ± 0.10
7	0.53 ± 0.20*	0.51 ± 0.10*	0.88 ± 0.23	0.58 ± 0.04
8	0.39 ± 0.26*	0.35 ± 0.16*	0.75 ± 0.13	0.42 ± 0.05*
9	0.30 ± 0.28*	0.18 ± 0.08*	0.71 ± 0.19	0.35 ± 0.14*
10	0.23 ± 0.20	0.15 ± 0.03*,†	0.58 ± 0.28	0.34 ± 0.12
11	0.22 ± 0.19	0.07 ± 0.04*,†	0.47 ± 0.27	0.28 ± 0.11

Values indicate mean ± standard deviation.
* = P < 0.05, 5-min/10-min/control group vs 15-min group.
† = P < 0.05, 5-min/10-min vs control group.

3.2. Tissue damage, inflammation, fibroblasts, and reepithelialization

The results of the hematoxylin and eosin (H&E staining) in the epidermis and dermis are presented in Fig. 3 and Table 2. The number of inflammatory cells in the 10-min group was significantly lower when compared to the 5-min (P = 0.04), 15-min (P = 0.015), and control groups (P = 0.011), while inflammation in the 5-min group was significantly lower when compared with the control group (P = 0.04) and 15-min group (P = 0.011). When comparing the inflammatory cells in the control group to that in the 15-min group, the number of inflammatory cells in the control group was significantly lower compared to that in the 15-min group (P = 0.04)

The fibroblast intensity is presented in Table 2. The intensity of fibroblast in the 10-min group was increased when compared with the 5-min group. However, there was no significant difference between these two groups (P = 0.490). The intensity of fibroblast was higher in the 5-min and 10-min groups when compared with the control and 15-min groups (5-min vs control; P = 0.04, 5-min vs 15-min; P = 0.01, 10-min vs control; P = 0.032, 10-min vs 15-min, P = 0.013). The appearance of reepithelialization is shown in Fig. 4, which shows that reepithelialization was more advanced in the 5-min and 10-min groups when compared with the control and 15-min group. The most advanced reepithelialization occurred in the 10-min group. The 15-min and control groups showed minimal reepithelialization from the wound edge toward the center of the wound. The center of these groups was still uncovered with epithelial cells.

3.3. Collagen alignment

The result of Van Gieson staining in the dermis layer are shown in Fig. 5, which show that the density of collagen fibers was more obvious

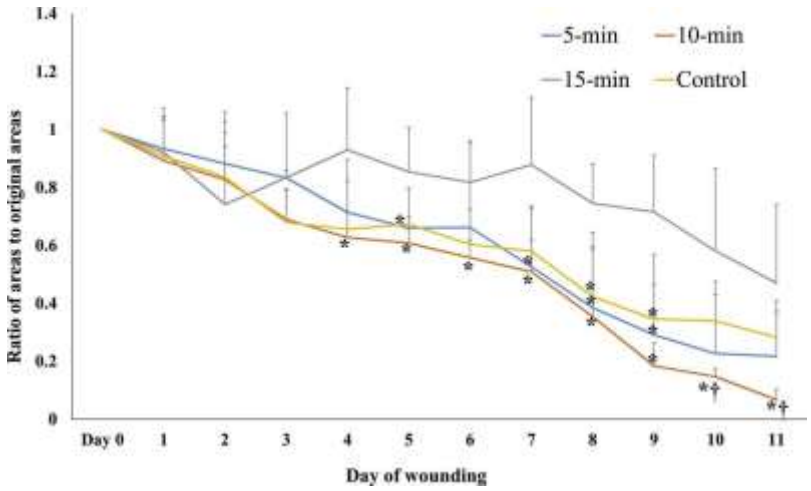

Fig. 2. Changes in wound size in each group from day 0 onwards (n = 5).

in the 5-min and 10-min groups than in the control and 15-min groups. Moreover, collagen alignment in the 5-min and 10-min groups revealed a proper alignment of collagen deposition, while in the other groups less and irregular arranged collagen fibers were observed. The 15-min group and the control group showed little deposition of collagen fibers. When comparing the 5-min and 10 min groups, the collagen deposition in the 10-min group was more increased, well aligned, and denser when compared with 5-min group.

3.4. Immunohistochemistry

Fig. 6 shows the MMP-9 positive cells in the dermis layer for each group. Positive MMP-9 cells were indicated by brown colored fibroblast cells. Most positive cells were located in the dermis layer. The comparison of the number of MMP-9-positive cells is shown in Fig. 7. In general, the number of MMP-9 positive cells in the 10-min group was lower when compared to that in other groups, however, no statistical differences in the number of MMP-9-positive cells were observed among the four groups.

Data regarding VEGF-positive cells are shown in Fig. 8. VEGF-positive cells were indicated by brown colored fibroblast cells. The differences in number of VEGF-positive cells are presented in Fig. 9. Fig. 9 shows that the intensity of VEGF-positive cells in the 10-min group was significantly higher compared to that in the 5-min ($P < 0.001$), 15-min group ($P < 0.001$) and control groups ($P < 0.001$). The number of VEGF-positive cells in the 5-min group was significantly higher when compared to that in the 15-min group ($P < 0.001$) and control groups ($P = 0.047$). Moreover, the 15-min group was more likely to have a lower number of VEGF-positive cells when compared to the control group, however no statistically significant differences were observed in the number of VEGF-positive cells between the 15-min and control groups.

Table 2
The level of inflammation and fibroblasts per group.

Groups	Polymorphonuclear neutrophils (PMNs)	Fibroblast
5-min	2†,≠	3†,≠
10-min	1*,†,≠	3.5†,≠
15-min	4	2
Control	3†	2

Values represent the median score.
Rating scale: 0 = absent, 1= occasional, 2 = moderate, 3 = abundant, 4 = very abundant.
* = $p < 0.05$ (10-min vs 5-min).
† = $p < 0.05$ (5-min/10-min/control vs 15-min).
≠ = $p < 0.05$ (5-min/10-min vs control).

4. Discussion

To our knowledge, this is the first study in which short duration of ES on wound healing was investigated. In this study, we compared the

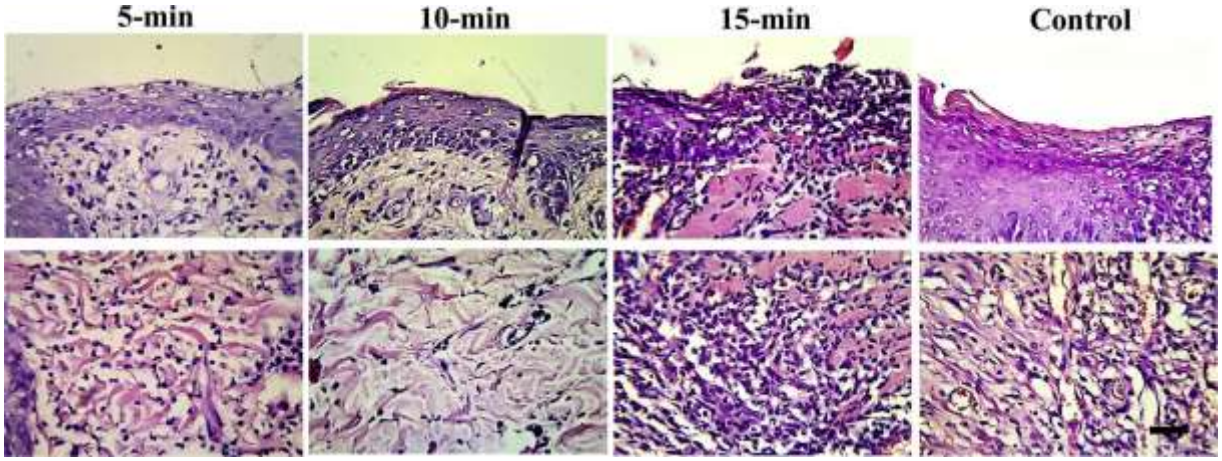

Fig. 3. Hematoxylin and eosin staining of the 5-min, 10-min, 15-min, and control groups on day 11 in the epidermis (upper picture) and dermis (lower picture) (bar = 100 μm).

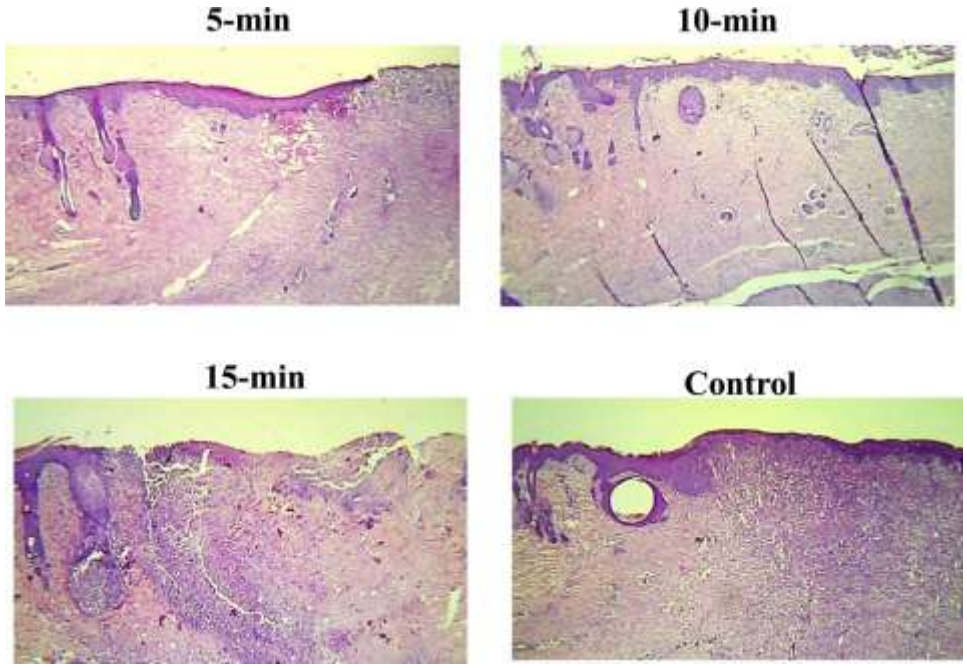

Fig. 4. The appearance of reepithelialization in the 5-min, 10-min, 15-min, and control groups on day 11 at (magnification 200×).

application of short duration (5-min, 10-min, and 15-min) of ES on wound healing of acute wounds. Wound healing was more improved in the application of ES 10-min when compared to the 5-min and 15-min groups.

Excessive inflammation will impede wound healing [29]. Our histological results showed that the application of 5-min and 10-min ES decreased inflammation when compared with the control group. The results of our study corresponds with the findings of our previous study and that of other studies that showed that ES reduced inflammation [20,21,33,34]. The mechanism by which ES reduced inflammation might involve the ability of ES to reduce the migration of excessive neutrophils, monocytes, and macrophages to the sites of injury [34]. In

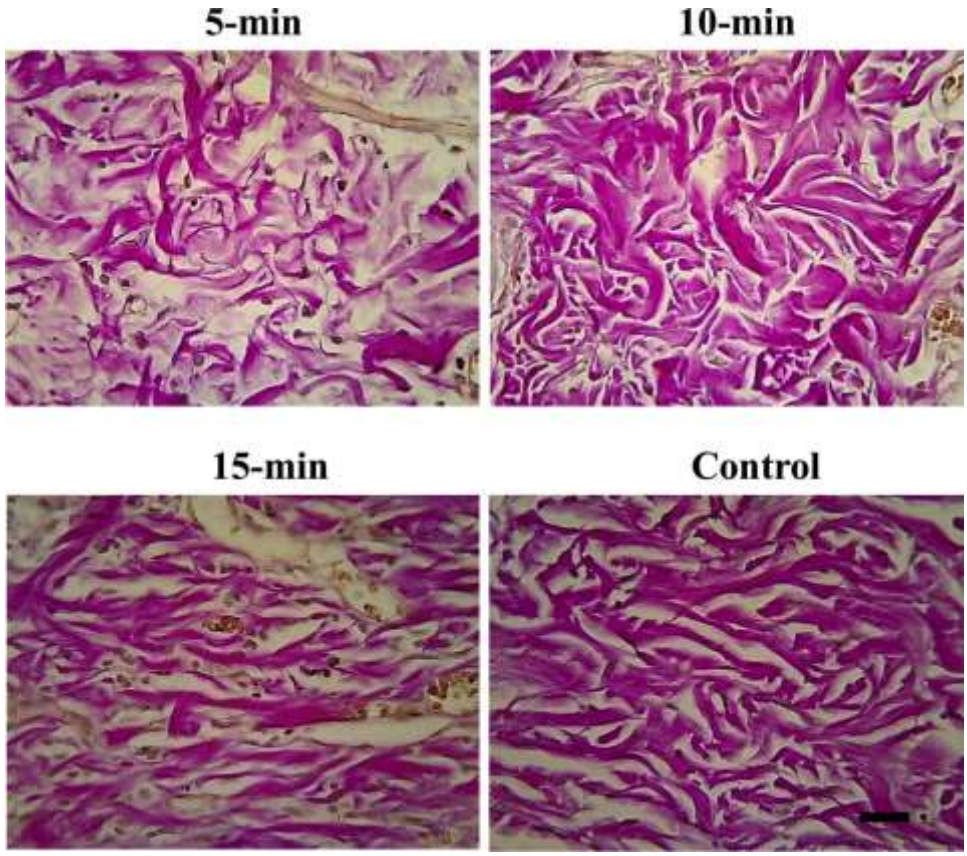

Fig. 5. Van Giesson staining in the 5-min, 10-min, 15-min and control groups on day 11 (bar = 100 μm).

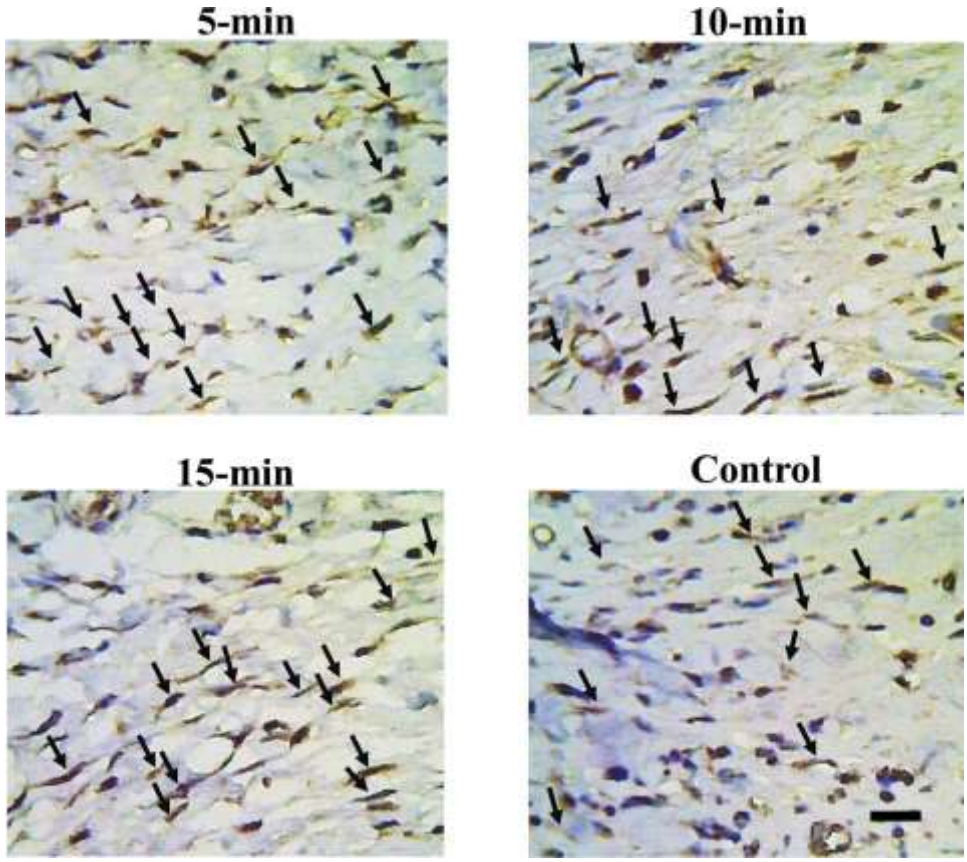

Fig. 6. MMP-9-positive cells in the dermis in the 5-min, 10-min, 15-min, and control groups on day 11 (n = 5) (bar = 100 μm). (For interpretation of the references to colour in the text, the reader is referred to the web version of this article.)

a previous study, it was shown that ES shortened the longer inflammation phase by decreasing the number of CD3+ cells [34]. In our study, the level of inflammation seen in the 15-min group was higher when compared with that of the control group. It may be suggested that the ES application of 15-min causes vasoconstriction of blood vessels, resulting in the reduction of oxygen. In a previous study by Morton et al. (1994), it was revealed that the reduction of oxygen during ES will cause an increase of reactive oxygen species (ROS) [35]. The increase in ROS will lead to the increase of inflammatory cells to the site of injury, leading to more excessive inflammation and tissue damage [35].

In our study, we showed that ES improved the reepithelialization of wounds. Wounds treated for 5 minutes and 10 minutes showed improvement of reepithelialization as was shown by the H&E staining when compared with the control group. The data obtained in our study corresponds with the data presented in a previous study that revealed that ES improved reepithelialization [36]. The improvement of reepithelialization might be due to the ability of ES to induce keratinocyte migration [12]. In addition, in a previous study, it was shown that ES increased levels of Col IV, which is a connective tissue promoter of keratinocytes, in the wound areas [34]. The increase in Col IV will

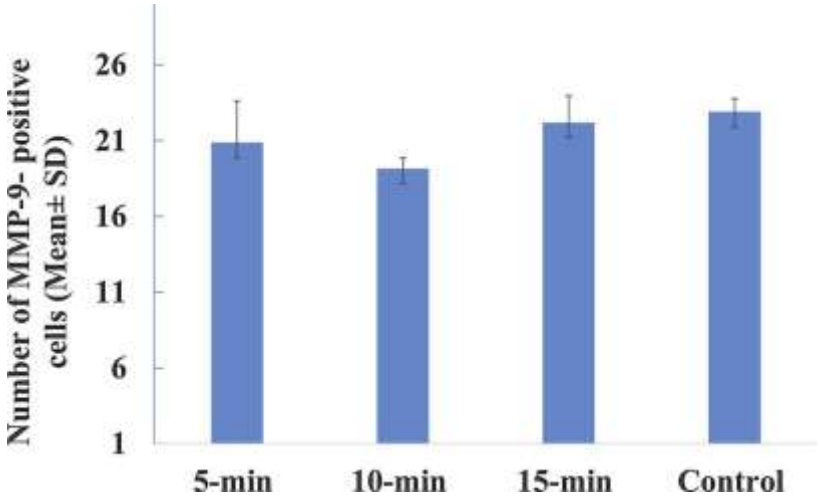

Fig. 7. Level of MMP-9-positive cells among the 5-min, 10-min, 15-min, and control groups on day 11. No significant differences were observed among the four groups.

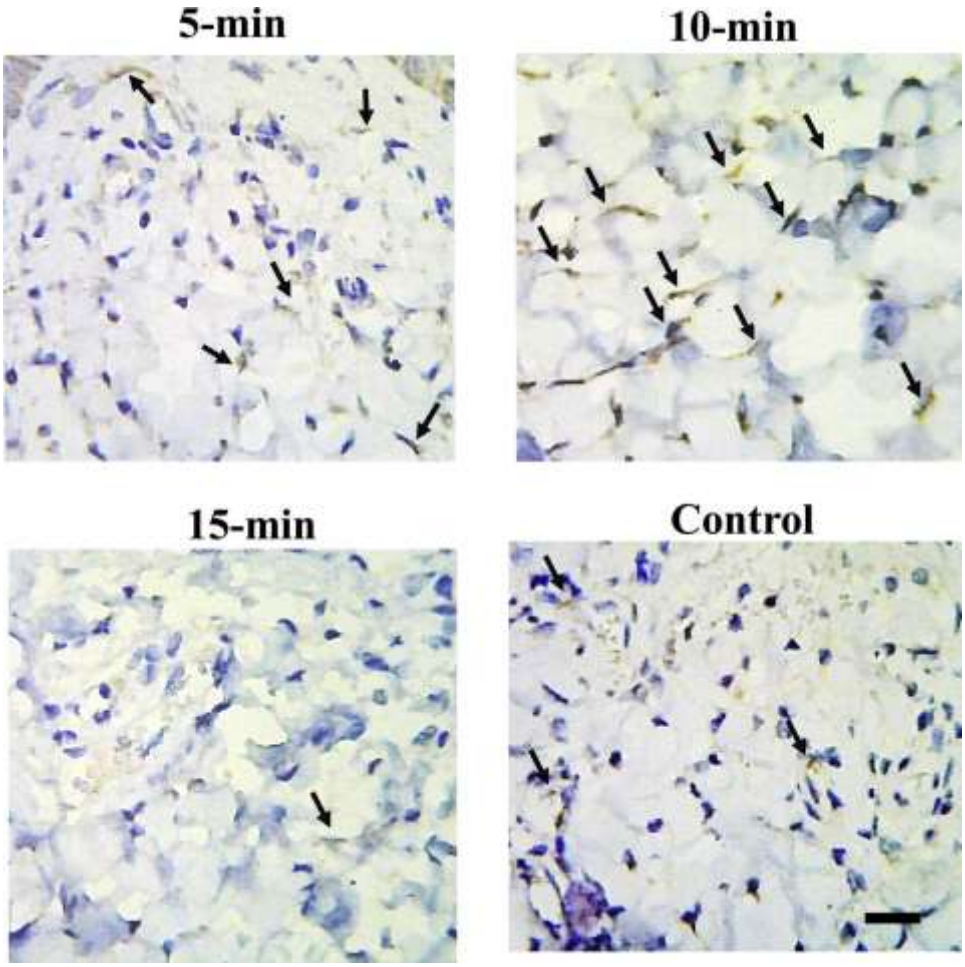

Fig. 8. VEGF-positive cells the dermis in the 5-min, 10-min, 15-min, and control groups on day 11 (n = 5) (bar = 100 μm). (For interpretation of the references to colour in the text, the reader is referred to the web version of this article.)

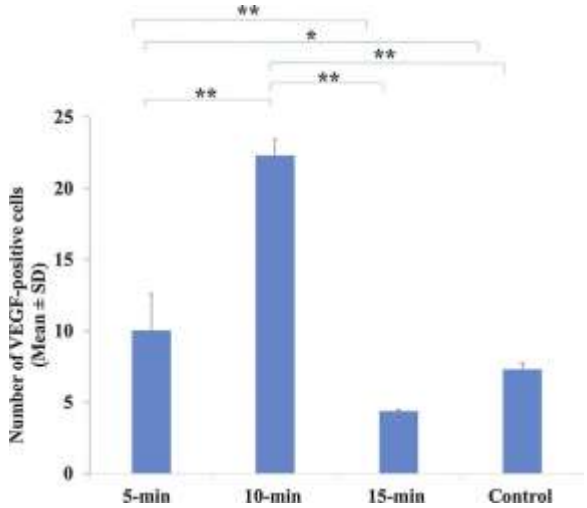

Fig. 9. Differences in the level VEGF-expressing cells among the 5-min, 10-min, 15-min, and control groups on day 11. *=P < 0.05, **= P < 0.01 (Tukey's test) (n = 5).

enhance keratinocyte proliferation and reconstitution of the basement membrane [34]. In this study, we observed that in the 15-min group, there was disruption of new epidermis by excessive inflammatory cells, resulting in delayed reepithelialization process. Thus, the influx of inflammatory cells might be due to the increase in ROS due to vasoconstriction of the blood vessel. In our study, we also found that the application of short duration of ES improved granulation tissue. On day 11, in the 10-min group was covered with granulation, while the control group was still covered with slough. Based on the previous study, ES improved the blood flow in wounded areas [37]. The improvement of granulation tissue might be due to the increase of blood flow in the wound bed when compared with the control group. The improved blood flow will cause a reduction of necrotic tissue in the wound bed. In our study, the improved blood flow in the 10-min group was observed by an increase in VEGF positive cells when compared with the control group. In this study, the application of ES for 5 minutes might not improve blood flow as much as in the 10-min group, indicating that VEGF positive cells were increased in the 10-min group when compared with the 5-min group. Therefore, the 5-min group was still covered with necrotic tissue on day 11. Further studies involving measurement of blood flow are needed to elucidate these findings.

Prolonged and excessive production of MMP-9 will lead to disordered wound healing [29]. In a previous study, it was shown that chronic wounds, such as diabetic ulcers and pressure ulcers had higher levels of MMP-9 [30]. In our study, the number of MMP-9 positive cells were not different among the four groups. This is a surprising result given that in previous study it was shown that the application of ES caused downregulation of MMP-9 [38]. This is also a new finding in this study that the improvement of wound healing following treatment with short duration of ES might not due to reduction of MMP-9. Taken together, further studies are needed to confirm the above-mentioned findings.

Angiogenesis is the process in which new blood vessel (capillaries)

forms in the wound site [39,40]. Insufficient angiogenesis causes a delay in wound healing and formation of a chronic wound [37]. In our study, application of ES for 5 minutes and 0 minutes increased the number of VEGF-positive cells in wounds. Our data corresponded with the findings presented in a previous study about the effect of ES on angiogenesis [37]. In previous studies it was shown that ES induced angiogenesis through enhanced VEGF production by endothelial cells [34,37]. In this study, the number of VEGF-positive cells in the 15-min group was lower when compared with that in the control group, which did not receive ES. Based on these results, it might be suggested that the application of 15 min induced vasoconstriction of blood vessels, rather than improved blood flow into wounded areas.

This study has some limitations. In our study, we only investigated a single time point. The effect of short ES application might be different on other phases of wound healing, such as inflammation and the maturation phase. Next studies in which different times of ES application are needed. In our study, we used one condition of stimulation (20 Hz, 320 μs, 50 μA). Therefore, the conclusion is limited to the present stimulation condition. However, this study also had strength that is worth to note. This study has high originality since it is the first study to investigate the effect of short duration of ES on wound healing. Moreover, this study has an impact on the use of ES in the clinical setting, especially for elderly who suffer from other disease and morbid conditions, and cannot use long application of ES.

5. Conclusion

This is the first study to investigate the effect of short duration of ES on wound healing. Our study showed that the application of ES for 10-min significantly reduced inflammation, improved reepithelialization and angiogenesis when compared to shorter and longer applications. ES for 10 minutes also significantly improved wound healing when compared to the use of modern dressing alone. It is recommended to apply ES for 10 minutes a day to improve wound healing.

Conflict of interest

The authors declared no potential conflicts of interest with respect to publication of this article.

Funding

The authors received a grant from the ministry of research, technology and higher education, Indonesia for the study and publication of this article (068/ADD/SP2H/LT/DRPM/VIII/2017).

Ethical approval

The Institutional Ethics Committee of Medical faculty, Universitas Jenderal Soedirman, Indonesia approved this study (1208/KEPK/III/2017)

Acknowledgments

We thank Selinna Nur Annisa, Putri Pirda E, and Marchanah for their help in conducting experiments involving animal subjects.

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Dokumen pendukung luaran Tambahan #2

Luaran dijanjikan: Prosiding dalam pertemuan ilmiah Internasional

Target: sudah terbit/sudah dilaksanakan
Dicapai: Published

Dokumen wajib diunggah:
1.

Dokumen sudah diunggah:
1. Artikel yang terbit

Dokumen belum diunggah:
-

Peran penulis: first author
Nama Konferensi/Seminar: 1st International Conference on multidisciplinary approaches for sustainable rural development
Lembaga penyelenggara: LPPM Unsoed
Tempat penyelenggara: Hotel Java Heritage
Tgl penyelenggaraan mulai: 14 November 2018 | Tgl selesai: 16 November 2018
ISBN/ISSN: 1755-1315/1755-1307
Lembaga pengindeks: scopus
URL website: http://icma.lppm.unsoed.ac.id/
Judul artikel: A low-frequency of electrical stimulation improves wound healing

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IOP Conf. Series: Earth and Environmental Science ***255*** (2019) 012014 doi:10.1088/1755-1315/255/1/012014

A low-frequency of electrical stimulation improves wound healing

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Abstract. High frequency of electrical stimulation (ES) can cause patients to become uncomfortable. Therefore, it needs to use a low frequency of ES. However, the use of low frequency of ES (below 20 Hz) on wound healing is still unclear. Therefore, this study aimed to elucidate the effect of low frequency (10 Hz) of ES on wound healing. A wound with a diameter of one cm was created at the dorsal side of rats. The rats were divided into two groups; low frequency of electrical stimulation (LFES), and control group (without ES application). The application of ES was given for ten days. The wound size in the LFES group was smaller in LFES group compared to the control group. The intensity of polymorphonuclear neutrophils was lower in the LFES group, while the intensity of fibroblast was significantly higher in the LFES than in the control group. The formation of new epidermis (reepithelialisation) was faster in LFES group than in the control groups. Low frequency of ES (10 Hz) accelerated wound healing by reducing inflammation, improving the fibroblast intensity, and formation of new epidermis.

1. Introduction

The increase of the aging population will increase the pathological condition related to aging, such as the development of wound. The previous study revealed that up to 3% of aged people in United States (above 65 years old) developed a wound during a lifetime [1]. This number might be higher in the developing countries [1]. If these wounds are not treated well, it leads to the development of chronic wounds. Previous studies showed that the cost of treatment of chronic wounds was above $50 billion per year [1-3]. Since the occurrence of the wounds will cause such impacts, therefore many researchers tried to find wound care therapies that can accelerate wound healing.

One of wound care therapies that can accelerate wound healing is electrical stimulation (ES). Electrical stimulation is the adjunct therapy that can deliver electrical currents to the targeted skin or tissue [4]. Electrical field will occur in our body when there is disruption in our skin [5]. This electrical field will help the epithelial migration during wound healing, resulting in faster wound closure [4]. Previous studies showed that electrical stimulation could promote wound healing not only in acute wounds [6], but also in chronic wounds [7, 8].

Most of previous studies related with electrical stimulation used the frequency above 50 Hz [9-13]. Franek et al [9] and Ahmad [10] showed that frequency of 100 Hz accelerated wound healing of pressure ulcers, while Houghton et al.[11] showed that 100 Hz improved wound healing of leg ulcers. Jancovic [12] studied that frequency of 1000 Hz improved the healing of leg ulcers, while Ud din et al. [13] used 60 Hz to improve dermal scar. All the above studies showed that the application of ES above 50 Hz could improve wound healing.

Our previous studies showed that the application of ES with frequency of 20 Hz could improve wound healing in chronic wound (diabetic ulcer) [14,15]. Our recent unpublished study also found that the best duration application of ES was 10 minutes a day. However, up to present, the effect of low frequency of ES below 20 Hz is still unclear. If the low frequency below 20 Hz of ES can also improve wound healing, it will be beneficial in the clinical setting, since the low application of ES may make the patients more comfortable during the application of ES. Previous study showed that application of high frequency of ES sometimes causes patients to become uncomfortable. Therefore, the purpose of this study was to investigate the wound healing of low frequency of ES on wound healing of acute wounds.

2. Method

2.1. Animal

Male Wistar rats at the age of 12 weeks were used to make rat model in this study. The animals body weight were 180-200 miligram. These rats were purchased from Purwokerto Muhammadiyah University, Purwokerto, Indonesia. The acclimatization period after purchasing was 7 days before treatment. The procedure of this study was approved by ethical committee, Faculty of Medicine, Universitas Jenderal Soedirman, Purwokerto, Indonesia.

2.2. Wounding method and treatment

After acclimatization for seven days, the hair of rats then was shaved. Before wounding procedure, the rats were injected with ketamile hydrochloride 90 mg/Kg of body weight. A wound with diameter of one cm was created at the dorsal region of rats. After wounding, the rats were divided into 2 groups, low frequency of electrical stimulation (LFES) and control group. LFES group received the low frequency of ES and standard treatment (covered with parafilm dressing), while control group only received standard treatment (covered with parafilm dressing). After wounding, the wounds in both groups were cleansed with normal saline solution (NaCl 0.9 %) and covered with parafilm dressing. Then, wound in the LFES group received ES application (10 Hz) for 10 minutes. The application of ES was based on previous studies [14,15]. The wounds in the LFES group were treated from day 0 to day 10 with ES. Every day the wounds in both groups were monitored and photographed. Any changes in the wounds were recorded. There was no rat died during wounding procedure and application of ES.

2.3. Hematoxylin and Eosin staining

The skin samples were taken on day 11. The skin tissue (wound tissue and normal tissue near the wound) were immediately immersed into formalin 10 %. The tissue was then processed in graded alcohol and xylene for Hematoxylin and Eosin staining (H and E). The tissue section was then observed under light microscope under magnification of 400X or 100X. The difference in the intensity of polymorphonuclear neutrophils (PMNs) and fibroblast was assessed based on the previous study [16].

2.4. Statistical analysis

Mann-Whitney-U test was used to assess the difference in the intensity of PMNs and fibroblast between LFES group and control group. The value of p less than 0.05 was considered significant. The statistical analysis used SPSS program version of 23.

3. Result and discussion

The result were discussed in three sections; they are wound bed appearance, histological analysis in epidermis and dermis layer, the intensity of PMNs and fibroblast, and reepithelialisation

3.1. Wound bed appearance

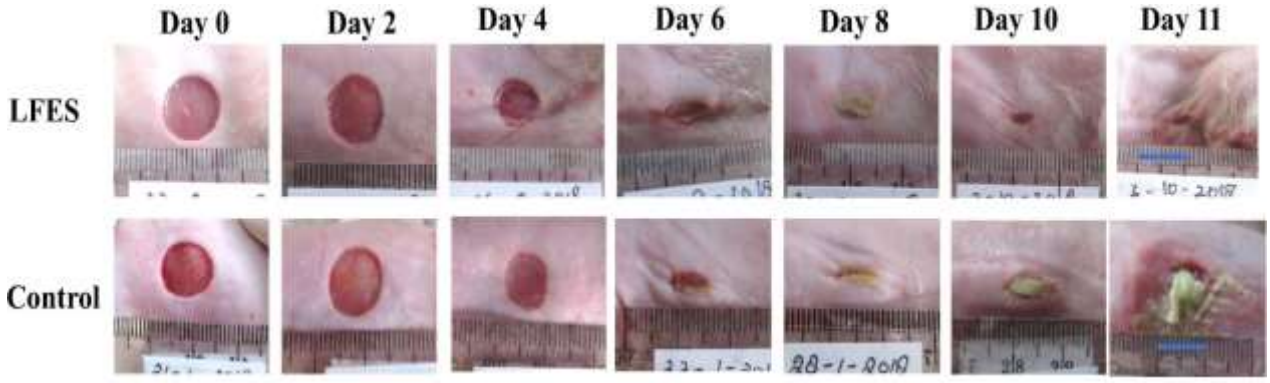

Figure 1. The appearance of the wound

On day 0, the wound bed color in the LFES group had a same color with wound in the control group. On day 2, the appearance of the wound bed in the LFES group still had similar appearance like in the control group. On day 4, the appearance of the wound bed in the LFES and control group was still similar, however the size of wound in the control group was wider compared with LFESgroup. On day 8, the slough (necrotic tissue with yellow color) could be observed in both groups, however, the slough in the control group was larger compared with LFES group. On day 10, the slough was not present in the LFES group, while it was still present in the control group. On day 11, the wound in the LFES group was almost healed, and already covered with new epithelial cells, however, wound in the control group was still covered with slough. Moreover, the surrounding tissue was also red in the control group, indicating extensive inflammation into surrounding tissue. The exudate was not present on day 11 in the LFES group, however, the exudate in the control group was still present and the color was purulent.

Based on figure 1, the wound in the control group was still covered with slough when the wound in the LFES group was already covered with granulation tissue. The presence of slough indicates the reduction of blood flow in the wound [17]. The reduction of blood flow will cause accumulation of dead cells in the wound bed. In the LFES group, the slough was not present on day 10, it indicated the application of LFES can improve the blood flow to the wounds, resulting in the removal of the slough from the wound bed.

On day 11, the wound in the LFES group had no exudate while wound in the control group had a purulent exudate. Moreover, there was a redness in the surrounding tissue. It might indicate that there was increased of bacterial burden in the control group, while there was reduction of bacterial burden in the LFES group. The reduction of the bacterial burden in the LFES group indicated that the application of low frequency of ES reduced the number of bacteria in the wounds. Our study corresponds with previous study that showed the application of ES could reduce the bacterial burden in the wounds. [18]. The type of bacteria could be inhibited or destroyed by ES were *Staphylococcus epidermidis, Staphylococcu aureus, P. aeruginosa, E. coli, and Klebsiella* [19,20]

3.2. Histological analysis in epidermis and dermis layer

The result of the histological analysis in the epidermis layer is shown in figure 2. The inflammatory cells was indicated by the cells which have blue color in the tissue. The inflammatory cells was rare in the epidermis layer of LFES group on day 11, however the inflammation in the control group was still

enormous. In the control group, slough was covered all part of the epidermis layer, while there was no necrotic tissue in the epidermis layer of LFES group. Figure 3 showed the histological appearance of dermis on day 11. Similar with the findings in the epidermis, the figure showed that the number of inflammatory cells in the LFES group in dermis was also less compared to the control group.

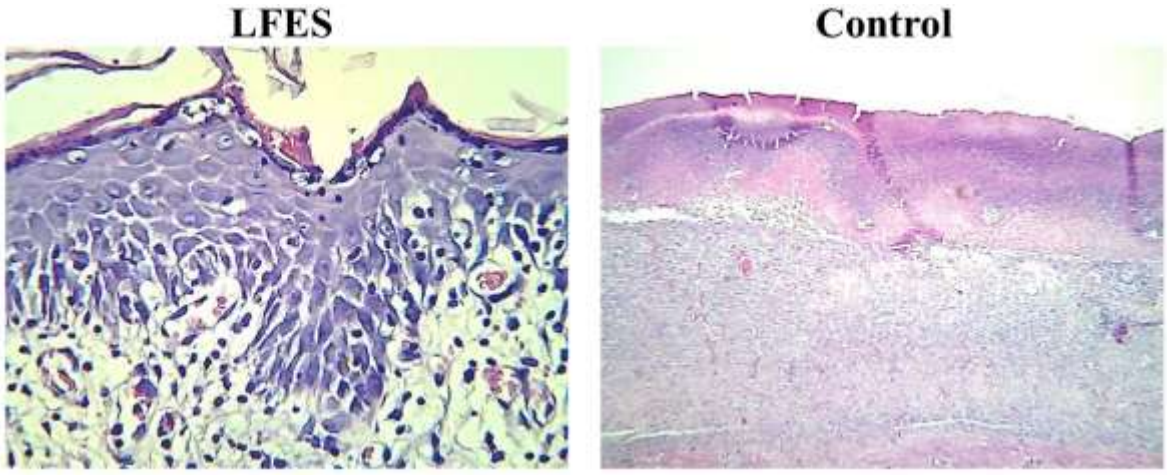

Figure 2. H and E staining of the epidermis layer of LFES group and control group (magnification of 400 X)

The presence of slough in the epidermis and dermis layer in the control group can cause spreading inflammation into the healthy tissue. Previous studies showed that inflammatory cells released reactive oxygen species that could increase oxidative stress in tissue [21]. The increase of oxidative stress would also increase the number of inflammatory cells in the tissue. In the LFES group, there was improvement of blood flow and therefore the production of ROS might be reduced, resulting in reduction of inflammation.

In the LFES group, the application of frequency under 20 Hz of ES reduced the migration of inflammatory cells (neutrophil and macrophage) to the wound site. Excessive migration of inflammatory cells will cause extensive inflammation in the wound site. Our study was in accordance with previous study that revealed the application of ES reduced the inflammation of the wounds [22]. Another mechanism of the reduction of PMNs in this study might also be involved. A previous study showed that ES can also caused the inflammation phase become shorter than wound not treated with ES since ES could reduce the number of CD3+ cells.[22]

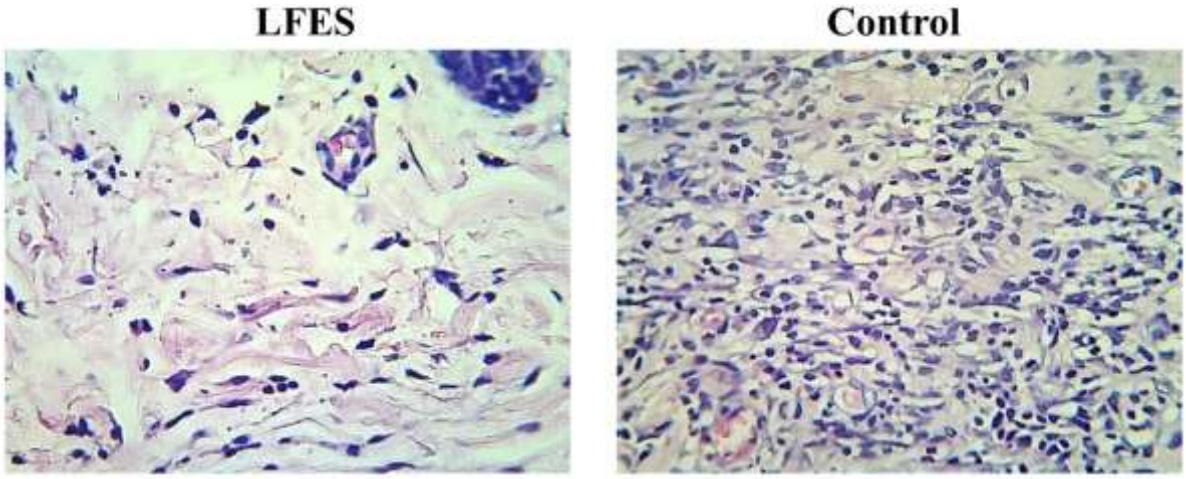

Figure 3. H and E staining of the epidermis layer of LFES group and control group (magnification of 400 X)

3.3. The intensity of PMNs and fibroblast

The intensity of PMNs and fibroblast on day 11 is shown in table 1. Table 1 showed that the intensity of PMNs in the LFES group was significantly lower (p=0.014) in the LFES group compared with control group. The intensity of fibroblast in the LFES group was significantly higher in the LFES group (p=0.018) compared with control group.

The improvement of the granulation tissue in the LFES group might due to the increase of the fibroblast in the LFES group. Fibroblast is mayor cells that deposit or produce granulation tissue. During wound healing process, fibroblast will proliferate and migrate to the injury site to produce extracellular matrix which act as a scaffolding during regeneration of tissue [23]. Fibroblast can also differentiate to become myofibroblast, which have a key in wound contraction process [24]. Fibroblast also has a critical role during wound angiogenesis, since fibroblast can produce and release vascular endothelial growth factor which has a role as proangiogenic mediators [25]

Table 1. The intensity of PMNs and fibroblast on day 11

Groups	PMNs	Fibroblast
LFES	2*	3*
Control	3.5	2

Values represent the median score. Scores can range from 0 4 absent (1 = occasional appearance; 2 = moderate appearance; 3 = abundant appearance; 4 = very abundant apperance). * p <0.05

3.4. Reepithelialization

Figure 4 showed the reepitheliazation in the LFES group and control group. The figure 4 showed that the wound reepithelialization in LFES group was longer than in the control group. The center of the wound in the LFES group was already covered with new epithelial cells, while the epidermis in the control group was not covered with new epithelial cells yet.

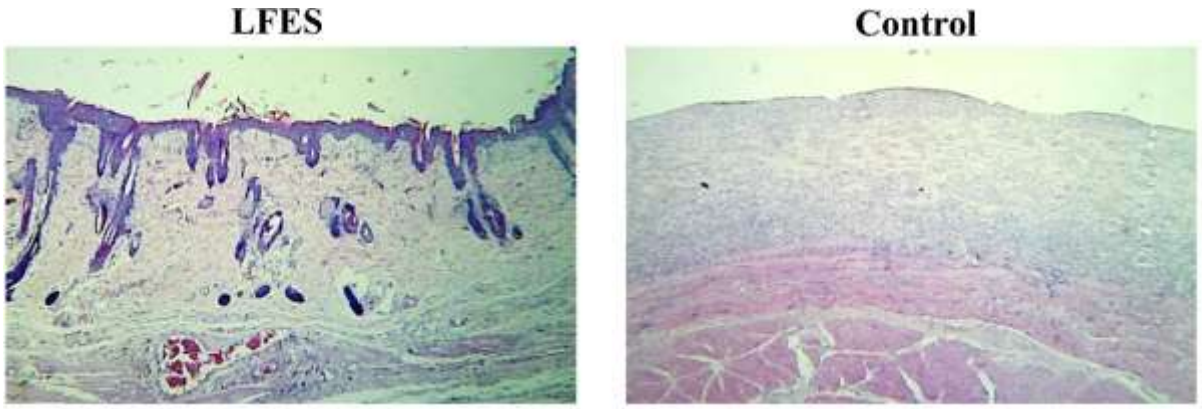

Figure 4. Repithelializatio between LFES group and control group (magnification of 100 X)

The disruption of the reepithelialisation in the control group might due to the extensive inflammation in the epidermis. The extensive inflammatory cells can increase the oxidative stress that can destroy the healthy tissue in surrounding areas. The ability of LFES in accelerate the reepithelialisation might due to the ability of ES to improve epithelial migration [25]. Our study was according to the previous study that revealed ES above 100 Hz improved the keratinocytes migration. Surprisingly, our study showed that the frequency of 10 Hz also improved wound reepithelialisation. Previous study showed that the improvement of reepithelialisation in LFES group might due to the ability of ES in increasing of Collagen IV, which is important for proliferation of keratinocytes.

4. Conclusion

The application of low frequency of ES (10 Hz) reduced the presence of slough, exudate, PMNs and increased fibroblast and improved reepitheliazation. Based on this study, it is suggested to use low frequency of ES (10 Hz) to treat acute wound in the clinical setting.

Acknowledgement

We thank the ministry of research, technology and higher education for supporting this study through a grant of Penelitian Unggulan perguruan Tinggi.

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Dokumen pendukung luaran Tambahan #3

Luaran dijanjikan: Produk

Target: penerapan
Dicapai: Produk

Dokumen wajib diunggah:
1. Deskripsi dan spesifikasi produk
2. Hasil uji coba produk terakhir
3. Dokumentasi (foto) pengujian produk

Dokumen sudah diunggah:
1. Deskripsi dan spesifikasi produk
2. Dokumentasi (foto) pengujian produk
3. Hasil uji coba produk terakhir

Dokumen belum diunggah:
-

Nama Produk: Stimulasi elektris
Pemegang Produk: Yunita Sari; Hartono; Eman Sutrisna
Tgl Awal Periode Uji: 2 Januari 2018
Tgl Akhir Periode Uji: 31 Oktober 2019
Link Video Dokumentasi Pengujian: https://www.youtube.com/watch?v=0lBmb7uBKaE

DESKRIPSI PRODUK ALAT STIMULASI ELEKTRIS UNTUK PERAWATAN LUKA DIABETES

Invensi bertujuan untuk menyediakan alat stimulasi elektrik. Alat stimulasi elektrik terdiri dari dua bagian, yaitu pembangkit pulsa elektrik dan pembangkit tegangan DC variabel. Pembangkit pulsa elektrik merupakan rangkaian elektronik yang dapat membangkitkan sinyal elektrik yang berupa gelombang persegi yang selanjutnya disebut dengan pulsa elektrik. Pulsa elektrik dibangkitkan dengan menggunakan rangkaian multivibrator astabil. Rangkaian multivibrator dapat menghasilkan pulsa elektrik yang dapat diatur frekuensi dan lebar pulsanya. Pembangkit tegangan DC variabel merupakan rangkaian elektronik yang dibuat untuk menghasilkan tegangan DC yang dapat divariasi nilai amplitudonya dari 0 volt sampai 60 volt. Pembangkit tegangan DC variabel dibuat menggunakan rangkaian pembagi tegangan. Sinyal listrik keluaran dari alat ini dihubungkan dengan penderita melalui sepasang elektroda. Sepasang elektroda direkatkan pada bagian kulit yang dikehendaki, sehingga akan terjadi aliran arus listrik ke dalam jaringan tubuh.

Komponen yang dibutuhkan pada pembuatan alat ini adalah yaitu elektroda dan catu daya.Bagian elektroda berfungsi sebagai penyalur arus listrik ke bagian tubuh yang dikehendaki. Elektroda dibuat sepasang dari bahan logam tahan korosi yang dapat dengan mudah ditempel pada bagian tubuh. Catu daya berfungsi sebagai penyuplai arus listrik pada kedua elektroda. Arus listrik yang dihasilkan oleh catu daya berupa pulsa listrik yang berbentuk gelombang kotak dengan amplitudo dan frekuensi tertentu yang dapat

divariasi. Variasi ini digunakan untuk mendapatkan nilai optimum terhadap proses penyembuhan luka.

Invensi ini bertujuan untuk menyediakan alat perawatan luka dengan prinsip stimulasi elektris yang memiliki karakteristik voltase sampai dengan 60 volt.

Uraian singkat Gambar

Gambar 1. Rangkaian Multivibrator astabil sebagai pembangkit pulsa elektrik

Gambar 2. Rangkaian pembangkit tegangan dc

Gambar 3. Susunan Rangkaian stimulasi elektrik

Uraian Lengkap Invensi

Invensi ini bertujuan untuk menyediakan alat stimulasi elektris. Alat ini dibuat dengan memanfaatkan komponen-komponen yang mudah diperoleh secara lokal sehingga mudah untuk diproduksi massal. Selain itu, pengoperasian alat ini juga sangat mudah.

Pembuatan stimulasi elektrik dilakukan dalam beberapa langkah, yaitu: a) membuat rangkaian pembangkit pulsa elektrik dengan multivibrator astabil (Gambar 1). Pembangkit pulsa dibuat dengan frekuensi dan lebar pulsa yang dapat diatur. b)memasang saklar putar untuk menentukan pilihan frekuensi dan lebar pulsa sesuai yang dibutuhkan. c)membuat pembangkit tegangan DC variabel. Pembangkit tegangan DC variabel dibuat untuk memvariasi amplitudo pulsa elektrik (Gambar 2). Rangkaian dibuat menggunakan konsep pelipat tegangan. d)memasang potensio untuk mengatur tinggi rendahnya amplitudo pulsa elektrik. Variasi tegangan dibuat menggunakan konsep pembagi tegangan, sehingga amplitudo pulsa dapat divariasi dari 0

sampai 60 volt e)menghubungkan rangkaian pembangkit pulsa dan pembangkit tegangan DC variabel menjadi satu rangkaian. f)memasang lampu indikator untuk menunjukkan range frekuensi dan lebar pulsa yang sedang digunakan. g)memasang voltmeter pada bagian keluaran rangkaian untuk melihat tegangan atau amplitudo elektrik. h)memasang ampermeter pada jalur keluaran untuk memantau arus listrik yang diinjeksikan ke tubuh (Gambar 3). i) memasang kabel penghubung yang dilengkapi dengan sepasang elektroda. Elektroda dibuat dari logam yang tidak korosi. Elektroda digunakan untuk menyalurkan arus listrik ke dalam tubuh. j)menguji sinyal keluaran stimulasi elektrik pada frekuensi dan lebar pulsa tertentu serta variasi tegangan dari 0 sampai 60 volt. k) melakukan pengemasan dalam sebuah bok untuk memudahkan penggunaan dan penyimpanan.

Stimulasi elektrik dibuat menggunakan komponen-komponen yang mudah ditemukan. Rangkaian pembangkit pulsa terdiri dari beberapa komponen, yaitu: IC NE555, 2 buah kapasitor dan 2 buah variabel resistor. Sementara pembangkit tegangan DC variabel terdiri dari transformator step down 1 ampere, 2 buah dioda bridge 1 ampere, 5 buah dioda daya 1N4005, 5 buah kapasitor non polar 100 nF dan 2 buah kapasitor polar masing-masing 1000 μF/16 V dan 100 μF/200 V. 5 buah dioda daya 1N4005 dan 5 buah kapasitor non polar digunakan untuk pelipat tegangan, sehingga dihasilkan tegangan sekitar 100 volt. Variasi tegangan dibuat menggunakan sebuah transistor mosfet IRF740 dan sebuah variabel resistor. Variabel resistor ini digunakan untuk memvariasikan tegangan DC dari 0 sampai 60 volt.

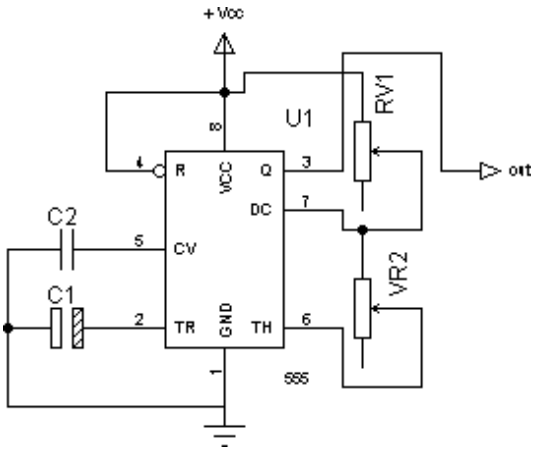
Dalam alat ini, IC NE555 sebagai otak dari rangkaian multivibrator bekerja secara bersama sama dengan komponen pendukung lainnya, yaitu resistor dan kapasitor. IC NE555 terdiri dari 8 pin. Pin 1 dan 8 sebagai input catu daya, yaitu jalur untuk memberikan tegangan masukan pada IC. Pin 2 sebagai trigger dan pin 5 untuk kontrol tegangan dihububgkan dengan kapasitor. Kapasitor akan terisi muatan listrik dan akan melepaskan muatannya kembali pada batas tegangan tertentu. Tegangan yang dilepaskan akan mentrigger IC untuk aktif. Kecepatan pengisian (charger)dan pelepasan muatan (discharger) pada kapasitor ditentukan oleh resistor yang terpasang melalui pin 6 dan 7. Pin 3 sebagai jalur output akan menghasilkan arus listrik yang terputus putus membentuk pulsa. Banyak sedikitnya jumlah pulsa dalam 1 detik (frekuensi) ditentukan oleh nilai resistor dan kapasitor.

Pemantauan tegangan dan arus keluaran alat stimulasi elektrik menggunakan voltmeter dan ampermeter digital. Kedua alat dipasang pada bagian keluaran arus listrik. Pulsa elektrik keluaran dari alat dihubungkan dengan tubuh melalui kabel penghubung yang sudah dipasang elektroda.

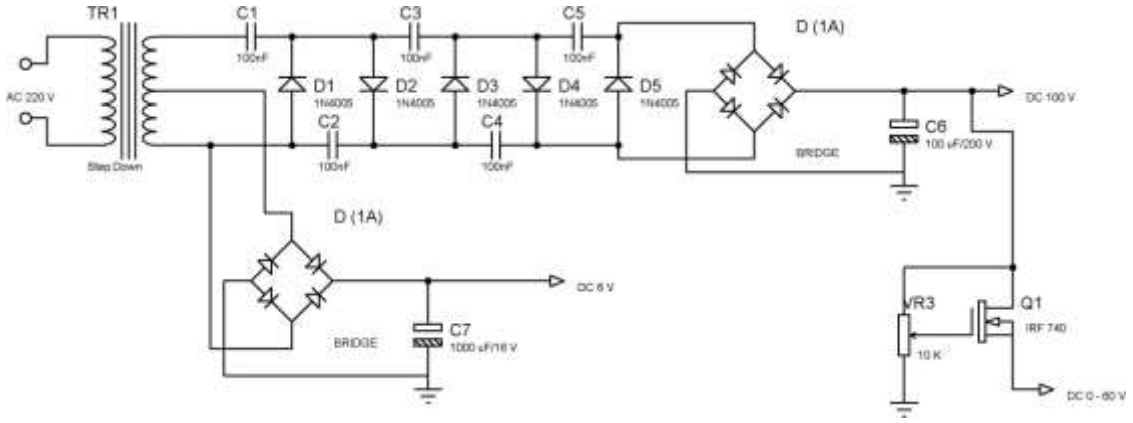
Pengoperasian alat stimulasi elektrik sangat sederhana. Langkah-langkah yang harus dilakukan adalah sebagai berikut: a)memasang sepasang elektroda di sekitar luka. b)menghubungkan konektor elektroda pada alat stimulasi elektrik. c)memastikan semua pengatur berada pada posisi minimum (posisi 0). d)menghubungkan kabel power ke listrik PLN. e)menghidupkan alat stimulasi elektrik melalui tombol power. f)menentukan frekuensi dan lebar pulsa menggunakan pengatur yang tersedia. g) mengatur tegangan keluaran stimulasi elektrik sesuai

dengan ketentuan menggunakan tombol pengatur tegangan dan melihat nilai tegangan dan arus pada voltmeter dan ampermeter.

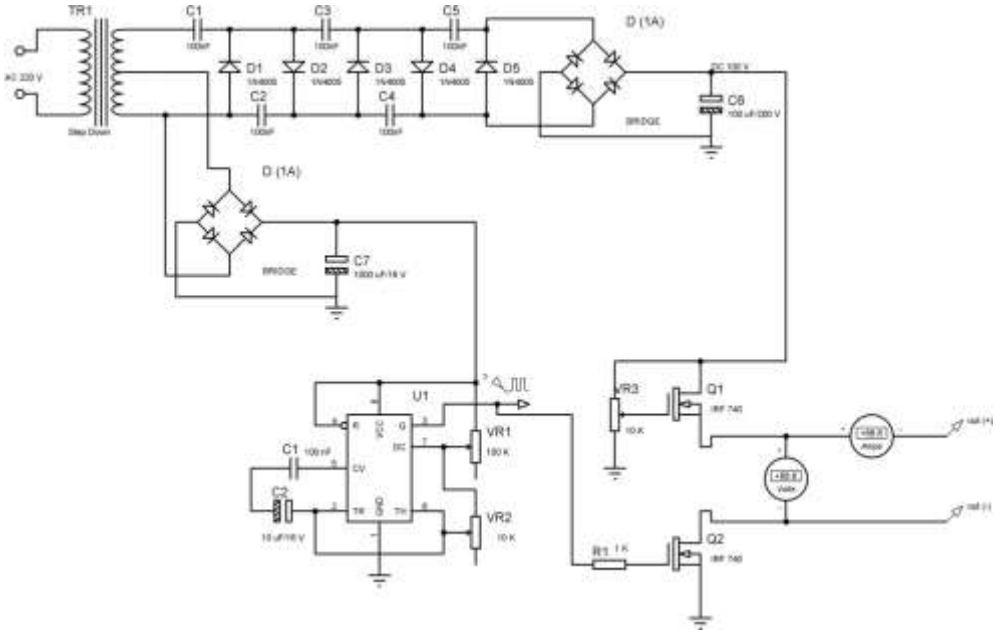
Prosedur mengakhiri penggunaan alat stimulasi elektrik juga sangat sederhana. Berikut adalah langkah-langkahnya, a)menurunkan tegangan sampai pada nilai 0 volt menggunakan tombol pengatur tegangan. b)mematikan alat melalui tombol power. c)mencabut kabel power dari listrik PLN. d)melepaskan elektroda dari tubuh dan melepaskan konektor dari alat stimulasi elektrik.



Gambar 1



Gambar 2



Gambar 3

Alat yang sudah jadi

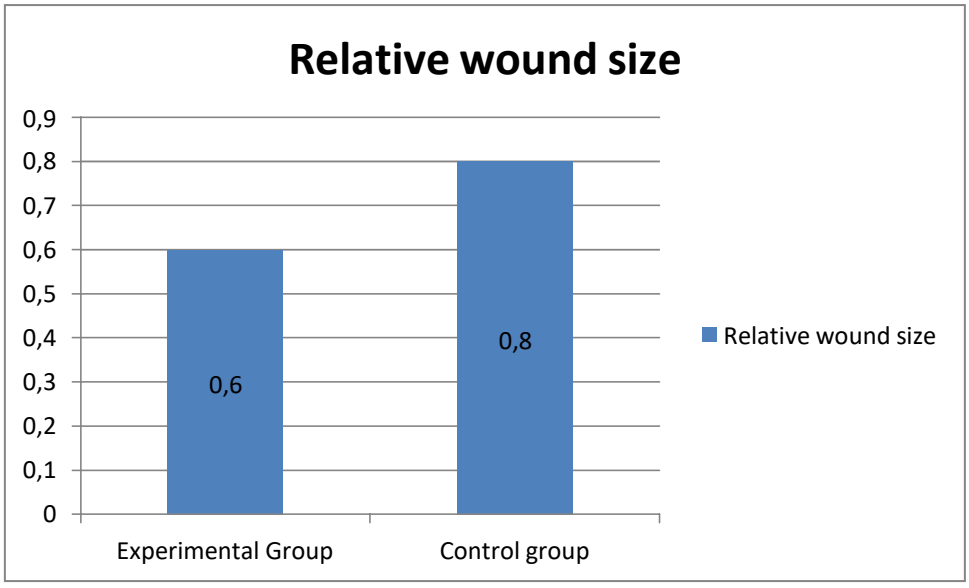
Dokumen Hasil Uji Coba

1. Semua pasien tidak menyatakan ada rasa nyeri saat aplikasi ES
2. Semua pasien tidak ada rasa terbakar saat aplikasi ES
3. Semua pasien menyatakan tidak ada rasa tidak nyaman saat aplikasi ES
4. Samples

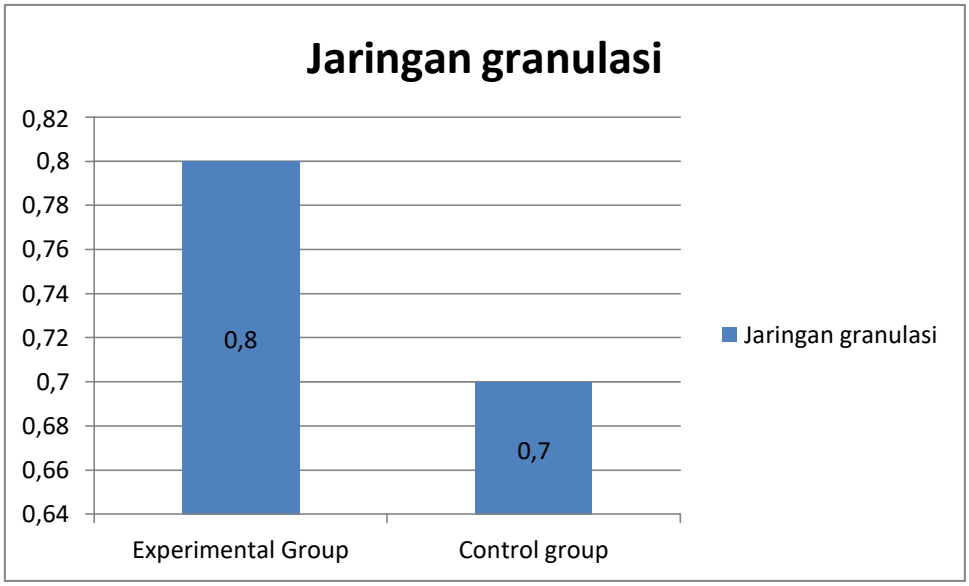
Jenis kelamin	Experiment	Control
Laki-laki	30	28
Perempuan	35	37

Hasil ujicoba ES pada penyembuhan luka

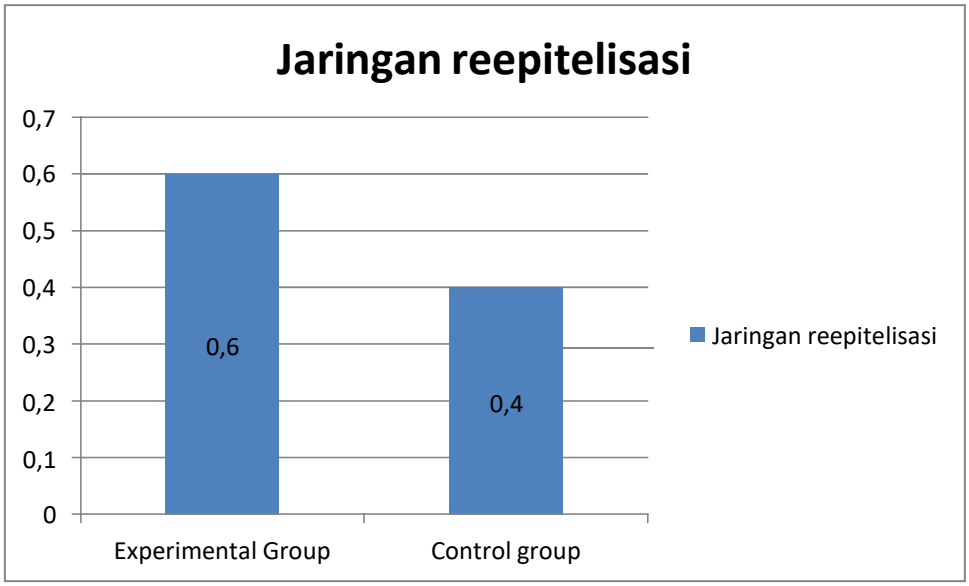
1. Ukuran luka antara kelompok experimental (aplikasi ES), dengan kelompok control (tidak dilakukan ES)



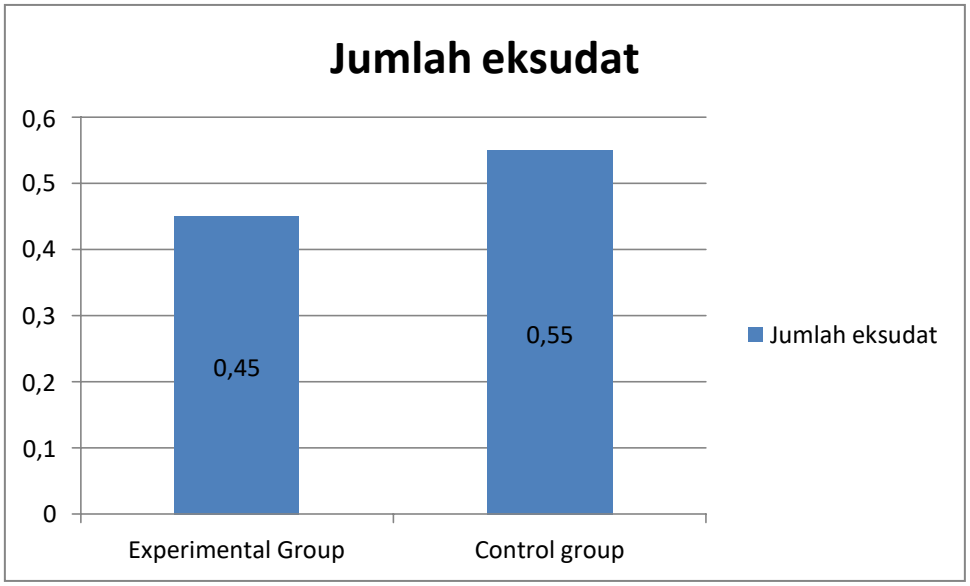
2. Tipe jaringan luka : jaringan granulasi lebih baik di kelompok experimental (aplikasi ES), dengan kelompok control (tidak dilakukan ES)

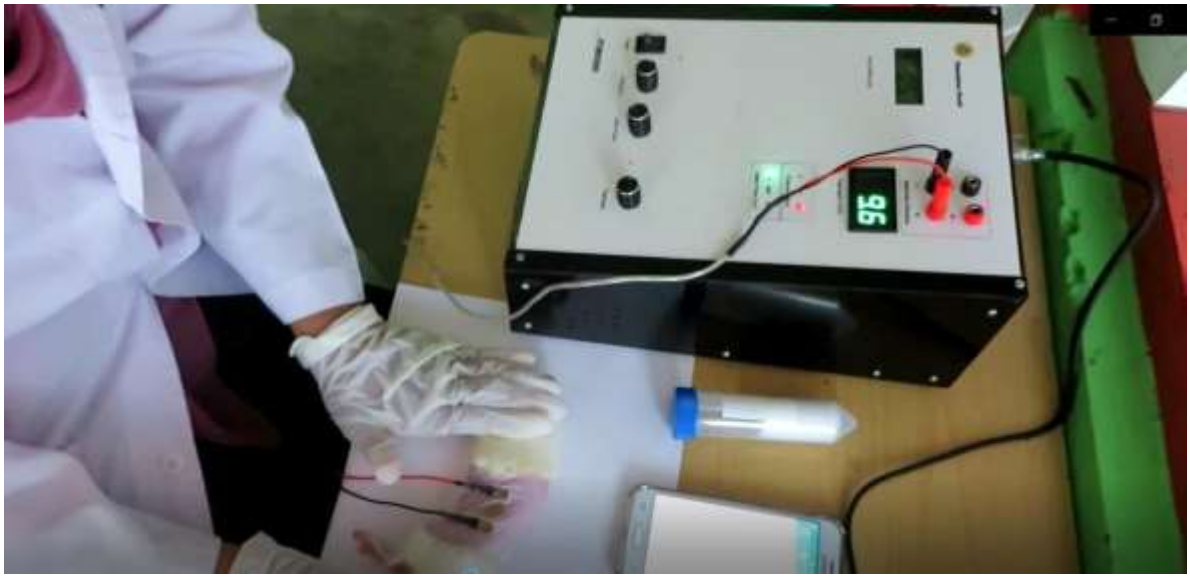


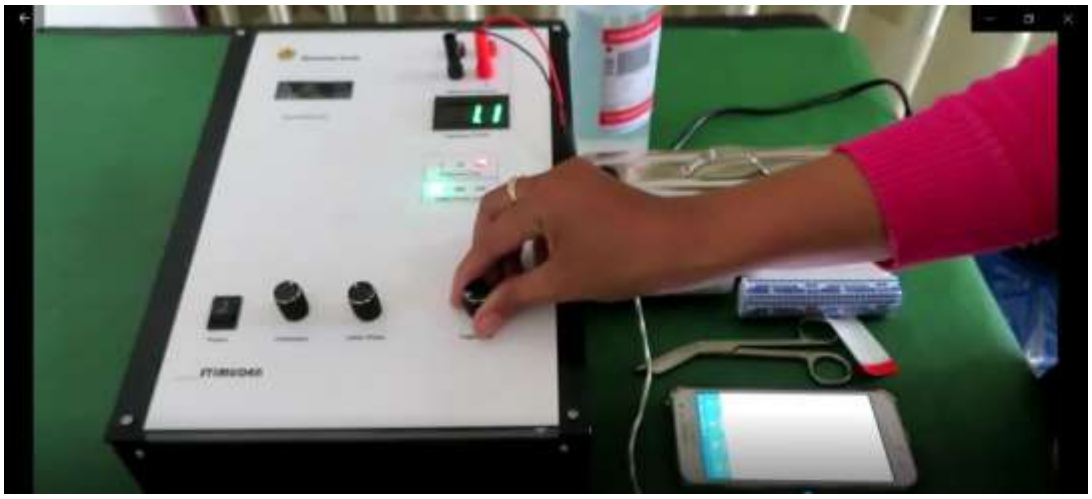
3. Jumlah jaringan reepitelisasi lebih baik dikelompok experimental

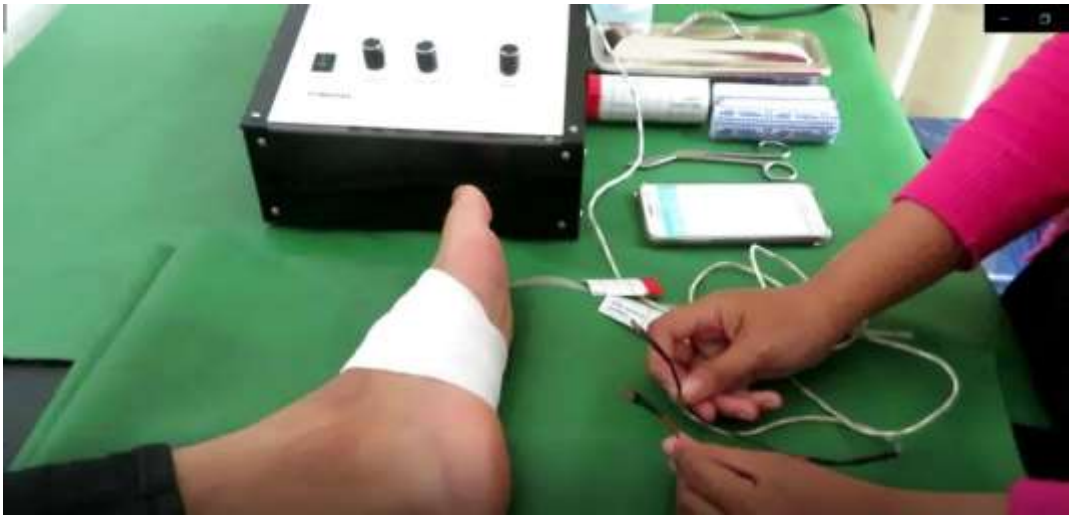


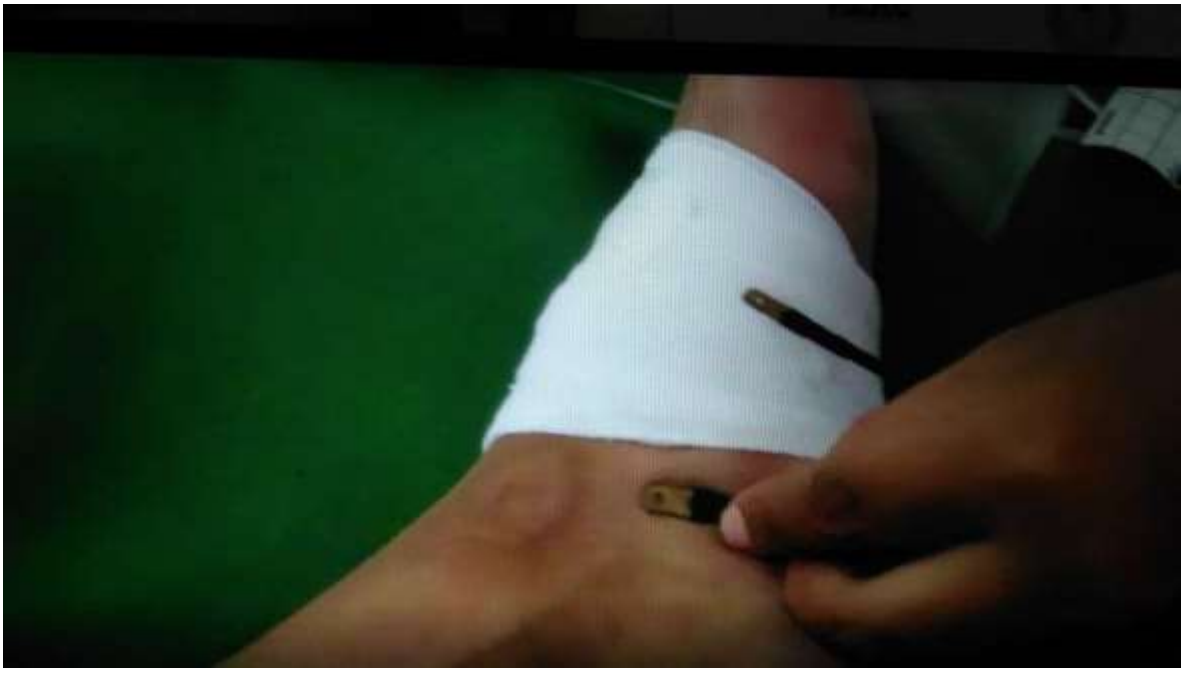
4. Jumlah eksudat

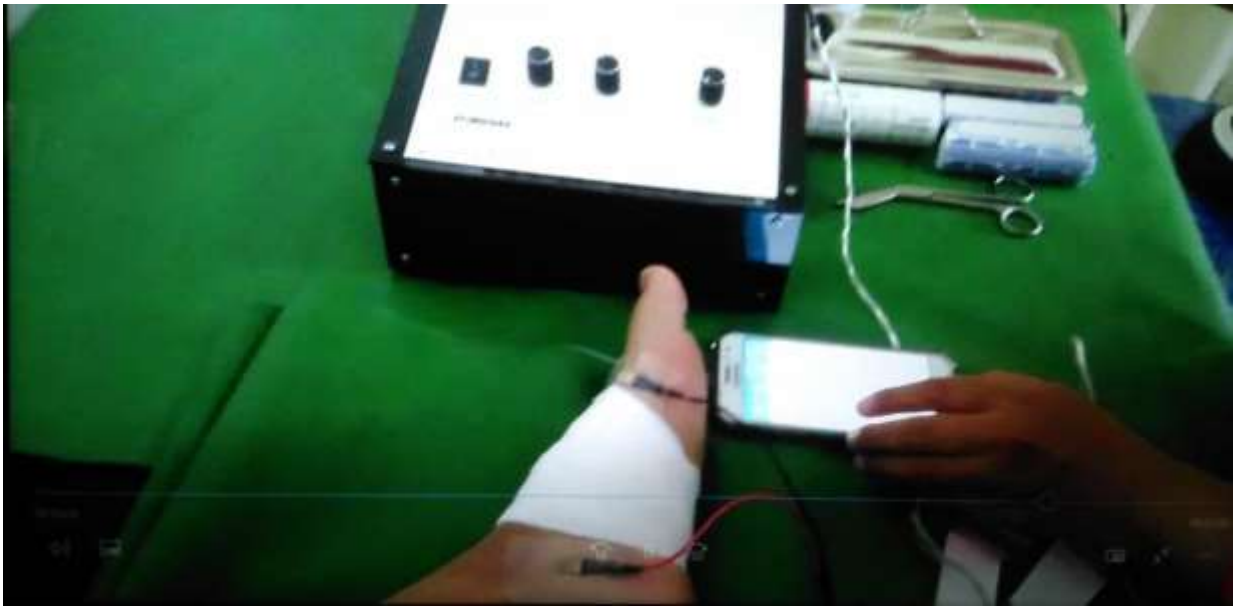

Jumlah eksudat
0,6
0,5
0,4
0,3
0,2
0,1
0
0,45
0,55
Experimental Group
Control group
Jumlah eksudat


96









Dokumen pendukung luaran Tambahan #4

Luaran dijanjikan: Buku Ajar (ISBN)

Target: sudah terbit
Dicapai: Terbit

Dokumen wajib diunggah:
1.

Dokumen sudah diunggah:
1. Surat keterangan terbit dari penerbit dengan menyebutkan jumlah eksemplar yg di cetak

Dokumen belum diunggah:
-

Judul Buku: Perawatan luka
Nama Penerbit: Unsoed Press
Website Penerbit: https://isbn.perpusnas.go.id/Account/SearchBuku?searchCat=Judul&searchTxt=Perawatan+luka%3A+buku+ajar
ISBN: 9786237144175
Tahun Terbit: 2019
Jumlah Halaman: 50
URL Buku: https://isbn.perpusnas.go.id/Account/SearchBuku?searchCat=Judul&searchTxt=Perawatan+luka%3A+buku+ajar

Buku Ajar

PERAWATAN LUKA

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Buku Ajar

PERAWATAN LUKA

Cetakan Kesatu, April 2019

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Diterbitkan oleh:
UNIVERSITAS JENDERAL SOEDIRMAN
Gd. BPU Percetakan dan Penerbitan (UNSOED Press)
Telp. (0281) 626070
Email: unsoedpress@unsoed.ac.id

Anggota
Asosiasi Penerbit Perguruan Tinggi Indonesia
Nomor : 003.027.1.03.2018

v + 50 hal., 15,5 x 23 cm

ISBN : 978-623-7144-17-5

DAFTAR ISI

BADAN PENGELOLA USAHA

UNSOED Press

Sampurna PRINT SHOP

Kampus UNSOED Grendeng, Jl. H.R. Boenyamin Purwokerto 53122
Telp. (0281) 626070 E-mail: unsoedpresspwt@gmail.com Website: press.unsoed.ac.id

Tgl. : 22 April 2019

Nama : By Yunita

Telp. : .....

Pesanan

Jenis	Ukuran	Jumlah	Harga
Cetak buku	15,5 x 23	10 eks	605.000
		@60.500	

LUNAS
08 MAY 2019

Catatan: Perawatan luka	Total	605.000
	UM	300.000
	Kurang	305.000

Mohon teliti kembali file Anda, kesalahan setelah naik cetak bukan tanggung jawab UNSOED Press.