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Modified application of dynamic wound closure system in the management of septic open abdomen

Fahri Yetişir[1], A. Ebru Salman[2], Fatih Özdemir[3], Doğukan Durak[1], Onur Özlü4, Mehmet Kılıç[1]

[1]Department of General Surgery, [2]Department of Anesthesiology and Reanimation, Atatürk Research and Training Hospital, Ankara
[3]General Surgery Department of İnönü University, Malatya
[4]Department of Anesthesiology and Reanimation, Numune Research and Training Hospital, Ankara

Background: We aimed to present the management of 6 cases of Open Abdomen with severe peritonitis and ostomies by the application of U shaped dynamic wound closure system (ABRA) in conjunction with VAC dressing in this case series.

Material and Method: Six open abdomen cases with severe peritonitis treated with modified application of ABRA in conjunction with VAC dressing between 2011 January and 2012 September were presented in this study. After hemodynamic stabilization in ICU, VAC dressing was applied and changed every 2-5 days until the fascia of patients was closed. The first modified application of ABRA (U shaped) was decided based on the clinical judgment. The arms of U shaped ABRA were placed on non-ostomy side of septic OA. When all the wound edges came across completely, it was sutured. One-two weeks after facial closure, the anchors of ABRA were removed.

Results: Mean APACHE II score was 23.67± 4.76. Mean Mannheim peritonitis index (MPI) score was 36.0±5.1, Björck OA score of 1 patient is 2b, 2 patients 3 and 3 patients, 4 at the time of first application of VAC dressing. Mean width and length of the abdominal defect was 20.5 ± 14.6 cm and 26.2 ± 8.7 cm respectively. There was no mortality. Successful delayed abdominal closure rate was 100%. Abdominal wall hernia developed in only 1 patient.

Conclusion: Modified application of ABRA decreases the cost of the treatment and provides more space for placement of ostomy bags in patients with ostomies in septic OA.

Key Words: dynamic closure, negative pressure, open abdomen, peritonitis.

Correspondence address and reprint request to: Dr. Fahri Yetişir, Department of General Surgery, Atatürk Research and Training Hospital, Ankara, Email: drfahriyetisir@hotmail.com

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Introduction

The management of open abdomen (OA) should be life-saving in abdominal compartment syndrome, damage control surgery after trauma and in case of

generalized peritonitis [1]. The patients with OA have a higher risk for developing major complications such as multiple organ failure, enterocutaneous fistula, intra-abdominal abscess, and abdominal wall hernia [2-6]. Risk of mortality is greater than 50% in the infected OA [2, 3].

The care of the patient with OA, techniques and timing of temporary abdominal closure creates a challenging clinical problem for surgeons and intensivists. Several methods such as Bogota beg, skin approximation, absorbable mesh, marlex with zipper, Wittman patch, Ramirez compartment separation technique, vacuum pack closure and vacuum assisted closure (VAC) dressing have been used for temporary closure of an OA with various success [1, 7, 8]. New and modern technologies including use of negative pressure therapy and synthetic or biologic repair materials are available for delayed closure of OA [2].

VAC dressing is an alternative technique for temporary covering with the benefits of evacuation of intra-abdominal exudates and edema and allowing control of abdominal volume and third space losses.

The dynamic wound closure system (ABRA; Canica Design, Almonte, Ontario, Canada) is a novel technique based on dynamic elastic closure to provide muscle and fascia reapproximation [9]. It is composed of silicone elastomers and button anchors basically. It has been used in OA of mainly non septic origin before [10].

We present the management of 6 cases of OA with severe peritonitis by the application of U shaped ABRA in conjunction with VAC dressing.

Material and Methods

Six cases with severe peritonitis of various origins between 2011 January and 2012 September were undergone first laparotomy. Control of sepsis of patients was established in ICU by mechanical ventilation, antibiotic treatment, fluid and electrolyte replacement. (Figure 1A, 1B) After hemodynamic stabilization in ICU, VAC dressing was applied for sequential lavage, evacuation of inflammatory exudates and reduction of edema under general anesthesia and was changed every 2-5 days until the fascia of patients were closed (figure 1C). The first modified application of ABRA was decided based on the clinical judgment, considering the hemodynamic status of the patient and after fistula was taken under control (Figure 1D, 2A). One surgeon applied the systems to all patients. Enteral nutrition was initiated when the intestinal continuity has been maintained [11].

Figure 1: (A), (B) Abdominal defect of a patient with intestinal fistula before application of VAC dressing and ABRA. (C) Iliostomy of the patient and application of VAC dressing. After first VAC dressing and ileostomy (D) Modified application of ABRA above the silicone sheet in conjunction with VAC dressing.

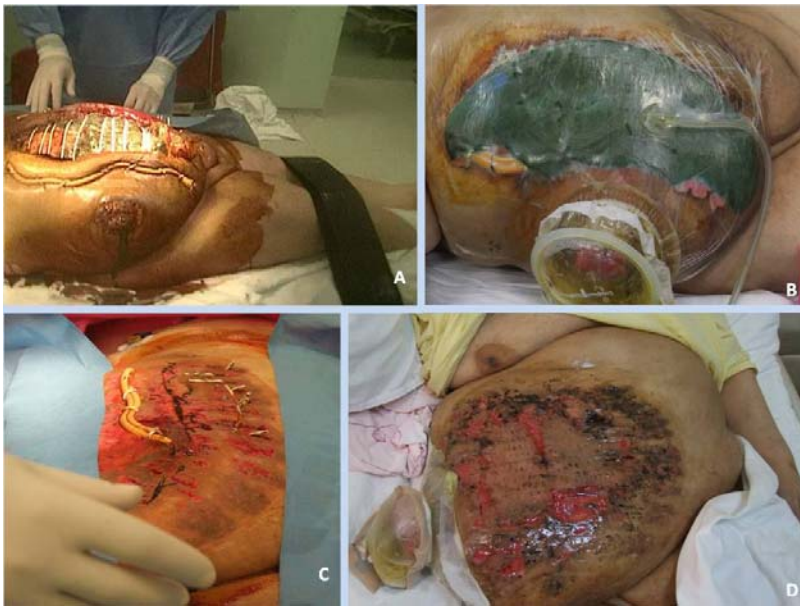

Figure 2: (A) Modified application of ABRA at the ostomy side. (B) Modified application of ABRA, conjunction with VAC dressing. (C) Closed open abdomen with anchors of ABRA removed partly. (D) Successful closed open abdomen.

The technique of VAC dressing

After debridement and irrigation of all quadrants of abdomen with warm saline, a perforated polyethylene sheet was placed over the bowel under the fascia in order to prevent adhesion of abdominal content to sponge and abdominal wall. Sponge was placed over the silicone sheet. Suction tubing was applied and sponge shrank. Negative pressure of VAC dressing was adjusted between (-50-125 mmHg) intermittently, 4 or 7 min of high negative pressure was followed by 1 or 2 min of low negative pressure respectively. The dressing is changed every 2-5 days under general anesthesia at the beginning and with sedation later on at bedside when the perforated silicone sheet is soiled with fibropurulant discharge. As closure progresses, the sheet and sponge was trimmed and placed under the front edge of the buttons.

The technique of modified application of ABRA system

The surgical wound was debrided then a series of midline crossing elastomers are surgically inserted through the full thickness of the abdominal wall at a distance of approximately 5 cm from the medial fascial margin by confirming U shape, arms of which were placed on the non-ostomy side with each elastomer. The elastomers are aligned about 3 cm part cross the defect and fixed to button anchors at the insertion side in only non-ostomy side of OA. The base of U shaped elastomer was passed by one or two 20 F Foley catheters placed side to side to prevent the development of pressure sores on the ostomy side of the OA. The Foley catheters were placed alternating the way they crossed at each elastomer, like braiding at every time VAC dressing was changed (Figure 1D, 2A,). A perforated silicone sheet was inserted between the abdominal wall and its contents and treated with VAC dressing (Figure 2B). The optimal tension was obtained by stretching the elastomers 1.5-2 their tension free length. Tension of modified ABRA was adjusted when VAC dressing was changed. If tension decreased to less than 1.25X it was tightened again to a maximum of 2X stretch. All patients received nonopioid analgesics for treatment of pain routinely. As rescue analgesics tramadol and or morphine was administered.

When all the wound edges came across completely, fascial edges were exposed by dissecting skin and subcutaneous tissue with the help of the cotter. Silicone drainage catheter was placed on each side and fascia was sutured one by one with PDS 1/0 without the need for additional mesh. Skin closure was performed 1–3 days after the fascial closure if there was no any infection or leakage at the wound side [12]. Drains were taken off, if the amount of drainage was <20

Table 1:Demographic characteristics of patients.

Patients No	BMI	Sex	Age
1.	19.0	M	22
2.	46.1	F	61
3.	16.3	F	57
4.	26.6	M	65
5.	21.5	M	38
6.	26.8	M	78

ml. The final step consisted of readjustment of ABRA system after fascial and skin closure, approximately 1–2 weeks after the closure of fascia, if there is no any dehiscence at wound, then the tension of ABRA was decreased step by step and the anchors of ABRA were removed one by one (Figure 2C,D).

All data are presented as mean and Standard Deviation.

Result

Demographic characteristics of six severely septic patients with OA were summarized in (Table 1). Etiology of first laparotomy of patients and cause and management of OA were given in (Table 2). APACHE II score, the Mannheim peritonitis index (MPI) score, Björck OA score at the

Table 2:Ethiology and management of OA

	Ethiology	First laparatomy	Cause of infected OA	Management of OA
1.	Multiple injuries to small bowel colon and lumbar vessels. Gunshot wounds	Partial resection, primary repair and anastomosis of small bowel and sigmoid colon resection and Hartmann procedurei	OA with colonic fistula with generalized peritonitis.	Drainage debridman + VAC + modified ABRA
2.	Strangulated and incarcerated giant recurrent hernia in a morbid obese patient (necrosis in small bowel)	Resection and anastomosis of small bowel+OA with Bogota bag.	Leakage of anastomosis and generalized peritonitis.	Ileostomi + VAC + modified ABRA
3.	Ileus in a patient with Abdominal Cocoon Syndrome related to peritoneal dialysis.	Brithectomy +Ileostomi	Enteric fistula and generalized peritonitis	Ileostomi VAC + modified ABRA
4.	Delayed diverticulitis perforation and generalized peritonitis.	Drainage + debridman and Hartmann procedure	Generalized peritonitis	Drainage + VAC + modified ABRA
5.	Right Colon Ca (GIS bleeding)	Right hemicolectomy+ ileotransverostomy	Leakage of anastomosis+ generalized peritonitis	Drainage+ ileostomy VAC + modified ABRA
6.	Ileus due to sigmoid colon ca	Left hemicolectomy+ resection + anastomosis	Leakage of anastomosis + generalized peritonitis.	Drainage+ debridman Hartmann procedure + VAC+ modified ABRA

Table 3: Characteristics of patients

Patients No:	Apache II score	Mannheim peritonitis index score	OA score according to Björck *	width of the bdominal defect, cm	Fascia Score **	Presence of colostomy	Presence of fistula
1	18	33	3	26x18	1	+	+
2	23	43	4	42x50	3	+	+
3	28	37	4	16x12	2	+	+
4	27	28	2b	25x15	1	+	-
5	18	37	4	21x14	2	+	-
6	28	38	3	27x14	1	+	-

*Bjorck classification of the open abdomen: 1A Clean OA without adherence between bowel and abdominal wall or fixity 1B Contaminated OA without adherence/fixity 2A Clean OA developing adherence/fixity 2B Contaminated OA developing adherence/fixity 3 OA complicated by fistula formation 4 Frozen OA with adherent/fixed bowel; unable to close surgically; with or without fistula OA Open abdomen(14)

**Fascia condition at the time of ABRA application was staged as a 3-point scale: 1, undamaged; 2, damaged and 3, severely damaged

time of first application of VAC dressing were documented in (Table 3) [13, 14, 15]. Width of the abdominal defect, condition of fascia, presence of ostomy and fistula were given in (Table 3). Timing and duration of VAC dressing and modified ABRA after first laparatomy and ABRA related pressure sore severity scores were summarized in (Table 4) [16]. The mean length of ICU and hospital stay was 11.2±3.6 and 54.0±16.2 respectively. Mean period of OA until final closure was 33±14.7 the mean follow up period was 15.7±8.8. There was no mortality. Abdominal wall hernia developed in one patient who had a very wide necrotizing fasciitis at the beginning of the treatment of OA. Silicone elastomers of ABRA could not be crossed from fascia. There was no need of any further reconstructive surgery during follow up period.

Discussion

Open abdomen is a common and compelling strategy applied to many traumatic and inflammatory abdominal conditions.

Table 4:Timing and duration of VAC and modified ABRA after first laparatomy and ABRA related pressure sore severitiy scores

Patients no:	Duration of OA until VAC application, (days)	Duration of OA until ABRA application, (days)	VAC treatment time (days)	ABRA treatment time (days	Severity score of ABRA related Barczak pressure sores*	
					Modified ABRA applied side	Classic ABRA applied side
1.	16	25	39	65	2	2
2.	7	22	48	60	2	3
3.	9	21	41	56	2	2
4.	8	11	18	45	2	2
5.	11	17	15	48	2	2
6.	9	13	18	50	2	2

*Pressure sores were staged according to Barczak et al.; stage 1, skin intact but reddened for greater than 1 h after relief of pressure; stage 2, blister or other break in dermis with or without infection; stage 3, subcutaneous destruction into muscle with or without infection and stage 4, involvement of bone or joint with or without infection(16)

Hemodynamic status of the patient, severity of peritonitis, degree of adherence or fixity between bowel and abdominal wall and condition of fascia are some of the complex factors influencing the success rate in patients with septic OA [17].

It was emphasized that patients with a Mannheim peritonitis index score of 20 or less was related to no mortality, of 21-29 with 29%, 30 or more with 100% mortality [13, 18]. The mean MPI score was 36.0±5.1in our study.

Verdam *et al* stated that two sided Velcro burr or Witmann mesh mediated fascial traction methods are suitable in early stages and or low grade OA. Mesh could not be used in infected OA. Verdam *et al* have emphasized that wound dehishence occurred in 2 patients Ramirez component separation method was used, one of whom died [1]. Therefore, Ramirez's 'component separation technique' should not be used as well in septic OA.

Steenvorde showed that use of negative pressure as a single method for the treatment of open abdomen failed because of the retraction of the abdominal muscles [19]. Failures and inadequacy of all the mentioned methods necessitate the use of combination of alternative techniques in septic OA.

Dynamic wound closure system offers a dynamic and continuously adjustable traction allowing both expansion and retraction in accordance with oscillation of breathing and patient movement by preventing further lateral retraction of the abdominal muscles and fascia [20]. Dynamic wound closure show its beneficial effects through multiple mechanisms at cellular level. Ott *et al* showed that up regulation occurs in the expression of connective tissue growth in cells exposed to mechanical stress [21]. It was also demonstrated that tensioned fibroblasts acquires a proliferative or biosynthetic phenotype [22]. It was also demonstrated by Langevin *et al* that fibroblast biosynthesis adapts to a proliferative phenotype as a result of stretching in mice [23].

Delayed primary closure rate in open abdomen was reported to be 33%-66% in previous studies [24, 25]. Reimer *et al* showed that complete primary closure was achieved with ABRA in patients with non-gastrointestinal pathology but OA of only 4 of 10 patients with gastrointestinal sepsis could be closed [10, 20]. Verdam *et al* stated that delayed closure was achieved at 88% in 16 patients within 30 days with ABRA combined with VAC dressing or Bogota beg [1]. We obtained 100% successful closure rate in our case series with our technique combining modified application of ABRA and VAC dressing. This difference in successful closure rates might be caused by the use of only VAC dressing in conjunction with ABRA in our study on contrary to previous study. We speculated that modified application of ABRA is best employed in combination with VAC dressing in septic OA.

Verdam *et al* have found that successful closure of OA without hernia was 55% in their study while it was 83% in ours. While primary abdominal closure was achieved by suturing both the fullthickness abdominal layer including fascia, muscle, and skin in this study, it was accomplished by suturing fascia and skin separetely in ours [1]. Elastomers were removed 1-2 weeks after fascial closure to prevent dehishence of the wound and debilitating abdominal wall hernias, since fascia is not strong enough thoroughly in these patients.

The development of the pressure sores caused by elastomer tensioning is one of the significant pitfalls of the system [10, 20]. It is a disturbing complication causing pain, discomfort and scarring. It was emphasized that additional padding of the buttons with gauze dressings may prevent the development of this complication. Verdam *et al* have found that grade 2 lesions developed in 6 of 18 patients. In 3 of these cases, deep subcutaneous necrosis developed [1]. In spite of the fact that careful and gentle tensioning of the elastomers and reduction of the tension when required, grade 2 lesion developed in 6 patients in ostomy side, and grade 2 and grade 3 lesion developed in 5 and in 1 patient respectively in non-ostomy side of all patients in our study (Table.4).

We use the modified application of ABRA dynamic fascial closure technique in order to

decrease the cost of the treatment by decreasing the number of button anchors to half. In our technique, anchors were not placed to ostomy side in order to provide more space for application of ostomy bag. We observed that modified application of ABRA in the shape of U, base of which is on the ostomy side, provides the optimal use of VAC dressing in the patients with ostomies.

Dynamic wound closure should be applied as early as possible after first laparotomy in order to achieve faster and higher closure rates by preventing the fascial retraction at regression of the intraabdominal sepsis.

Conclusion

In conclusion, modified application of ABRA decreases the cost of the treatment and provides more space for placement of ostomy bags in patients with ostomies in septic OA.

Authors' Contribution

FY: Study design, Study analysis, Writing, Data collection, Patient treatment and follow-up.
AES: Data analysis, Writing, Study analysis, Patient treatment and follow-up

Conflict of Interests

The authors declare that there are no conflict of interests

Ethical Considerations

The study was approved by Institute Ethics committee

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References

[1]. Verdam FJ, Dolmans D.E.J.G, Loos MJ, Raber MH, De Vit RJ, Charbon JA et al. Delayed primary closure of the septic open abdomen with a dynamic wound closure system. World J Surg 2011;35:2348-55. [Pubmed].

[2]. Diaz JJ Jr, Cullinane DC, Dutton WD, Jerome R, Bagdonas R, Bilaniuk JW, Collier BR, Como JJ, Cumming J, Griffen M, Gunter OL, Kirby J, Lottenburg L, Mowery N, Riordan WP Jr, Martin N, Platz J, Stassen N, Winston ES.The management of the open abdomen in trauma and emergency general surgery: part 1-damage control. J Trauma: 2010; 68: 1425–1438. [Pubmed].

[3]. Balogh Z, McKinley BA, Holcomb JB, Miller CC, Cocanour CS, Kozar RA, Valdivia A, Ware DN, Moore FA. Both primary and secondary abdominal compartment syndrome can be predicted early and are harbingers of multiple organ failure. J Trauma 2003;54:848–859 discussion 859–861. [Pubmed].

[4]. Gäddnäs F, Saarnio J, Ala-Kokko T, Laurila J, Koivukangas V. Continuous retention suture for the management of open abdomen: a high rateof delayed fascial closure. Scand J Surg 2007; 96:301–7. [Pubmed].

[5]. Perez D, Wildi S, Demartines N, Bramkamp M, Koehler C, Clavien PA. Prospective evaluation of vacuum-assisted closure in abdominal compartment syndrome and severe abdominal sepsis. J Am Coll Surg 2007; 205: 586-92. [Pubmed].

[6]. Nicholas JM, Rix EP, Easley KA, Feliciano DV, Cava RA, Ingram WL, Parry NG, Rozycki GS, Salomone JP, Tremblay LN. Changing patterns in the management of penetrating abdominal trauma: the more things change, the more they stay the same. J Trauma 2003;55: 1095–1108 discussion 1108–1110. [Pubmed].

[7]. Boele van Hensbroek P, Wind J, Dijkgraaf MG, Busch OR, Goslings JC. Temporary closure of the open abdomen: a systematic review on delayed primary fascial closure in patients with an open abdomen. World J Surg. 2009;33: 199-207. doi: 10.1007/s00268-008-9867-3. [Pubmed].

[8]. Ramirez OM, Ruas E, Dellon AL. Components separation method for closure of abdominal wall defects:an anatomical and clinical study.Plast Recons Surg 1990; 86:519-26. [Pubmed].

[9]. Urbaniak RM, Khuthalia DK, Khalil AJ, Hammond DC. Closure of massive abdominal wall defects .A case report using the abdominal reapproximation anchor system.Ann of Plastic Surg. 2006; 57:573-7. [Pubmed].

[10]. Reimer MW, Yelle JD, Reitsma B, Doumit G, Allen MA, Bell MS. Management of open abdominal wounds with a dynamic wound closure system. Can J Surg 2008; 51:209-14. [Pubmed].

[11]. Guillaume A, Seres DS. Safety of enteral feeding in patients with open abdomen, upper gastrointestinal bleed, and perforation peritonitis.Nutr Clin Pract 2012; 27:513-20. [Pubmed].

[12]. Salman AE, Yetişir F, Aksoy M, Tokaç M, Yıldırım MB, Kılıç M. Use of dynamic wound closure system in conjunction with vacuum-assited closure therapy in delayed closure of open abdomen. Hernia 2012. DOI 10.1007/s10029-012-1008-0. [Pubmed].
[13]. Bosscha K, Reijnders K, Hulstaert PF, Algra A, van der Werken C. Prognostic scoring systems to predict outcome in peritonitis and intraabdominal sepsis. Br J Surg 1997;84:1532–4. [Pubmed].
[14]. Björck M, Bruhin A, Cheatham M, Hinck D, Kaplan M, Manca G, Wild T, Windsor A. Classification— important step to improve management of patients with an open abdomen. World J Surg 2009;33:1154–7. [Pubmed].
[15]. Correia MM, Thuler LCS, Velascoı E, Vidal EM, Schanaider A. Prediction of death using the Mannheim peritonitis index in oncologic patients. Revista Brasil de Cancerologica 2001; 47:63-8.
[16]. Barczak CA, Barnett RI, Childs EJ, Bosley LM. Fourth national pressure ulcer prevalence survey. Adv Wound Care 1997;10:18–26. [Pubmed].
[17]. Tsuei BJ, Skinner JC, Bernard AC, Kearney PA, Boulanger BR. The open peritoneal cavity: etiology correlates with the likelihood of fascial closure. Am Surg 2004; 70: 652–6. [Pubmed].
[18]. Ohmann C, Wittmann DH, Wacha H. Peritonitis study group. Prospective evaluation of prognostic scoring systems in peritonitis. Eur J Surg.1993; 159: 267-74. [Pubmed].
[19]. Steenvorde P, Rozeboom AL, Melief P, Elzo Kraemer CV, Bonsing BA. Failure of topical negative pressure abdominal dressing system in the fat open abdomen: report of a case and review of literature. Wounds 2006; 18:44-50. [Full text]
[20]. Reimer MW, Yelle JD, Reitsma B, Doumit G, Allen MA, Bell MS. Management of open abdominal wounds with a dynamic fascial closure system. Can J Surg 2008;51:209-14. [Pubmed].
[21]. Ott C, Iwanciw D, Graness A, Giehl K, Goppelt-Struebe M. Modulation of the expression of connective tissue growth factor by alterations of the cytoskeleton. J Biol Chem. 2003; 278: 44305-11. [Pubmed].
[22]. Grinnell F. Fibroblast biology in threedimensional collagen matrices. Trends Cell Biol 2003;13:264-89. [Pubmed].
[23]. Langevin HM, Bouffard NA, Badger GJ, Iatridis JC, Howe AK. Dynamic fibroblast cytoskeletal response to subcutaneous tissue stretch ex vivo and in vitro.Am J Phsiol Cell Phsiol 2005;288:C747-56. [Pubmed].
[24]. Padalino P, Dionigi G, Minoja G, Carcano G, Rovera F, Boni L, Dionigi R. Fascia to fascia closure with abdominal topical negative pressure for severe abdominal infections:priliminary results in a department of general surgery and intensive care unit. Surg Infect (Larchmt) 2010;11: 523-8. [Pubmed].
[25]. Wondberg D, Larusson HJ, Metzger U, Platz A, Zingg U. Treatment of the open abdomen with the ommercially available vacuum assisted closure system in patients with abdominal sepsis:low primary closure rate. World J Surg 2008;32: 2724-9. [Pubmed].

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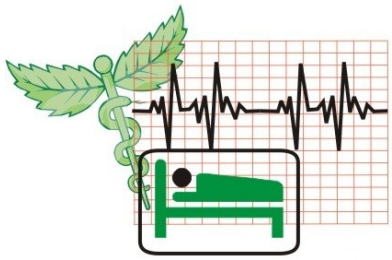

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