



HHS Public Access

Author manuscript

J Vasc Surg. Author manuscript; available in PMC 2017 December 01.

Published in final edited form as:

J Vasc Surg. 2016 December ; 64(6): 1770–1779.e1. doi:10.1016/j.jvs.2016.05.046.

Consensus recommendations for essential vascular care in low- and middle-income countries

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Abstract

Introduction—Many low- and middle-income countries (LMICs) are ill equipped to care for the large and growing burden of vascular conditions. We aimed to develop essential vascular care recommendations that would be feasible for implementation at nearly every setting worldwide, regardless of national income.

Methods—The normative Delphi method was used to achieve consensus on essential vascular care resources among 27 experts in multiple areas of vascular care and public health, as well as with experience in LMIC healthcare. Five anonymous, iterative rounds of survey with controlled feedback and a statistical response were used to reach consensus on essential vascular care resources.

Results—The matrices provide recommendations for 92 vascular care resources at each of the four levels of care in most LMICs (i.e. primary health centers, and first-level, referral, and tertiary hospitals). The recommendations include both essential and desirable resources and encompass the following categories: screening, counseling, and evaluation; diagnostics; medical care; surgical care; equipment and supplies; and medications.

Conclusion—The resources recommended have the potential to improve LMIC healthcare systems' ability to respond to the large and growing burden of vascular conditions. Many of these resources can be provided with thoughtful planning and organization without significant increases in cost. However, the resources must be incorporated into a framework that includes surveillance of vascular conditions, monitoring and evaluation of vascular capacity and care, a well functioning pre- and inter-hospital transport system, and vascular training for both existing and future healthcare providers.

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Conflict of interest

The authors have no real or potential conflict(s) of interest to disclose.

Author contributions

All authors participated in the design of the study, or the analysis and/or interpretation of the results. All authors provided substantial intellectual critique of the manuscript drafts. All authors approved the final version.

Keywords

vascular surgery; cardiovascular; developing country; global surgery; capacity

Introduction

Rapid population aging and increased exposure to modern risk factors (e.g. tobacco smoke, poor diet, sedentary lifestyles, road traffic) has created a large and increasing burden of non-communicable diseases (NCD) in low- and middle-income countries (LMICs);^{1,2} 7 out of 10 deaths in LMICs will be due to NCDs by 2020.^{3,4} In response, the World Health Organization (WHO) has set a target to reduce NCD deaths in people aged less than 70 years by 25% by 2025.^{5,6} While prevention, risk-factor reduction and a public health approach is fundamental to reducing the global NCD burden, planning NCD-related healthcare capacity improvements in LMICs is also important.⁷

Among NCDs, the increasing incidence of vascular conditions is particularly dramatically.² Population-based studies in the Central African Republic and Republic of Congo reported the prevalence of peripheral vascular disease (PVD; i.e. ankle-brachial index <0.9) to be between 12 and 32% of older adults.^{8,9} Studies from Ghana, South Africa, India, and Ecuador support these findings.¹⁰⁻¹³ The Global Burden of Disease 2010 study reported a nearly two-fold increase in PVD compared to the two previous decades; the rate of change was higher in LMICs than in high-income countries.¹⁴ Further, PVD is no longer a disease of the elderly, but now affects young adults, even in LMICs.¹⁵

Despite this burden, many LMICs still perform more vascular procedures for injury than for PVD. A tertiary center in Tanzania performed more than four times the number of amputations for trauma than for PVD.¹⁶ Similar reports from Nigeria, Kenya, and Iran suggest this is not an isolated pattern.¹⁷⁻¹⁹ Inopportunistly, the growing burden of vascular conditions falls on health systems that are not well equipped to provide essential trauma care, manage challenging vascular problems, or care for the unique requirements of the growing geriatric population.^{7,20,21} Sustaining these deficiencies is a lack of recommendations for LMIC healthcare systems to follow regarding the essential functions and resources for vascular care.

To address this gap, we aimed to develop recommendations for essential vascular care functions and resources that would be feasible for implementation in nearly every setting worldwide, regardless of national income. With sound planning and organization, the recommendations might improve care for people at risk of or with a vascular condition in LMICs, and prevent otherwise avertable death and disability.

Methods

Delphi method

We used normative Delphi methodology to develop consensus on recommendations for essential vascular care functions and resources (i.e. knowledge, skills, equipment, and supplies) in LMICs. The Delphi method is an iterative, anonymous, data-driven survey

method that facilitates expert-group consensus building.²² The four defining characteristics of the Delphi method were upheld throughout the process: anonymity; iteration; controlled feedback; and statistical group response.²³

Panelist selection

To ensure that the recommendations were both appropriate for low-resource contexts and represented quality vascular care, we approached experts that met the following criteria:

- professionals in LMICs or professionals that have significant experience working in LMICs (i.e. at least one cumulative year of work in a LMIC); and
- expertise in an area relevant to vascular care.

The areas of expertise included public health, vascular surgery, trauma surgery, anesthesia, primary care, cardiology, and cardiothoracic surgery. In total, 27 panelists took part in the consensus building process. All communication was blinded.

Survey methods

Panelists participated in five survey rounds. For each round, responses to open-ended questions regarding which resources to include or exclude, at what level of care, and why, were examined using a content analysis framework:²⁴ qualitative responses were grouped into categories based on codes that represented clustered responses; after, categories were further refined into useful themes and described. Responses were triangulated between panelists to evaluate the extent of theme convergence. Themes that emerged from the panelist responses were described to panelists in the following round to allow consideration before offering further recommendations.

In addition to open-ended questions, panelists were asked to rank proposed vascular care resources on a scale from 0 (i.e. not essential, do not include in the recommendations) to 10 (i.e. absolutely essential, must include in the recommendations) until consensus was achieved. Resources with a median rank ≤ 4 out of 10 were not included in subsequent rounds. Target consensus was defined *a priori* as: a median rank of ≥ 8 for each proposed resource on a scale from 0 to 10 *and* an average percent majority opinion (APMO) cut-off rate of ≥ 0.8 . The APMO cut-off rate is a consensus measure that is calculated by: adding agreements and disagreements; dividing the sum by all responses; and multiplying the result by 100%.²³ Agreement was defined as a resource rank of ≥ 7 ; disagreement was defined as a resource rank of ≤ 4 .

After consensus on the resources to be included in the recommendations was achieved, panelists assigned the level of care for which each resource should be 'essential,' 'desirable,' or 'irrelevant.' This system was used based on the success of the WHO *Guidelines for Essential Trauma Care* (GETC).²⁵ As in the GETC, we defined:

- Essential resources as those that: should be assured at the stated level regardless of national income; can be made available through better organization and planning without necessarily increased expenditure; and

add significant value that would increase the probability of a successful outcome.

- Desirable resources are those that: increase the probability of a successful outcome, but also add cost; desirable resources should be strongly considered by healthcare systems with greater resources or larger burdens of vascular disease.
- Irrelevant resources would not ordinarily be expected to be available at the stated level. Panelists assigned a designation (e.g. essential, desirable, irrelevant) to each resource at each level of care.

The resource designation with the greatest number of panelist assignments at each level of care was used for the recommendations. Panelists were instructed to align the recommendations with related WHO and The World Bank guideline documents (*Best Buys, Global Action Plan for the Prevention and Control of NCDs 2013–2020, Guidelines for Essential Trauma Care*), when appropriate, so that they fall within a coherent and externally validated framework for health systems in LMICs.^{25–28} However, some resources were considered to be particularly important for addressing the growing burden of vascular conditions in LMICs; thus, these were included in the present recommendations. SurveyMonkey (SurveyMonkey, USA) was used for data collection and Stata v13 (StataCorp, USA) was used for data analysis.

Survey rounds

The first three survey rounds were used to build consensus on which vascular care resources were to be included in the recommendations. Additionally, panelists proposed resources to be evaluated and offered comments on reasons that specific resources should be changed, removed, or added in the subsequent rounds. Each round was left open for panelists' responses for 3 weeks or until 23 of the 27 (85%) of panelists responded.

After each round, a summary of the comments was provided to the panelists so that they could consider the others' perspectives and ideas prior to the next ranking exercise. In the second and third rounds, resources without consensus (i.e. rank >4 and <7 out of 10) and newly proposed resources were re-ranked or ranked in light of the summary comments from the previous round. Consensus on the resources to be included in the final recommendations was achieved after third round.

Panelists' assigned each resource a designation (i.e. essential, desirable, or irrelevant) at each level of care in the fourth and fifth round. After the fourth round, a summary of comments was again provided to the panelists so that they could consider others' perspectives and ideas when assigning or critiquing designations in the final round.

Resource matrices

We used the resource matrix format used by the WHO, which is easily interpreted and has been widely adopted.^{21,29–35} In the matrices, resources are listed in the left-hand column, The level of care for which the resource designation corresponds is represented horizontally: primary health centers; first-level hospitals; referral hospitals; and tertiary hospitals. The

resource designations are listed vertically: E – essential; D – desirable; and I – irrelevant. Resources essential at one level are essential at all higher levels as well.

The nomenclature and capacity of these levels of care differ both between and within LMICs.³¹ For these recommendations, we used the definitions offered by the WHO and The World Bank:^{25,28,36}

- i. Primary health centers (PHCs) are located in communities countrywide, even in rural areas. In urban areas they represent outpatient clinics. The staffing of PHCs range from village health workers (i.e. no formal medical education; typically with a few months of health-related training) to general practitioners. PHCs are minimally equipped.
- ii. First-level hospitals are typically staffed by general practitioners (GP). These facilities may or may not provide surgical services, depending on the skill of the GP and the available resources. Some first-level hospitals are well-resourced and -functioning and perform the scope of first-level essential surgical care (e.g. those with a skilled surgical care provider, such as an experienced non-surgeon or a surgeon).³⁷
- iii. Referral hospitals are usually staffed by at least one specialist provider (e.g. internist; obstetric, general, and/or orthopedic surgeon). These facilities almost uniformly provide some range of diagnostic and surgical services.
- iv. Tertiary hospitals generally offer a broader range of specialties (e.g. cardiology, general surgery, orthopedic surgery). In addition, they have more advanced laboratory and diagnostic imaging capacity.

It is important to note that many individuals in LMICs face extraordinary barriers to care that prevent presentation or transfer to hospitals that are not in their community, regardless of the risk for death or disability.^{38–40} Further, most LMICs lack a formal, efficient, and free pre-hospital care and inter-hospital transfer system. The only care they might access, regardless of the acuity of their condition, may be a proximate first-level hospital.

Ethics

Consensus building amongst professionals met non-research criteria of the Stanford University Institutional Review Board (IRB); thus, requirement for IRB approval was waived.

Results

The matrices provide recommendations for 92 vascular care resources. These are divided into resources for: prevention, screening, counseling, and evaluation; diagnostics; medical care; surgical care; equipment and supplies; and medications.

Prevention, screening, counseling, and evaluation

There was strong consensus regarding the importance of cardiovascular health promotion, disease prevention, and risk factor identification. These capabilities are vital to population health and are low-cost; thus, they are recommended for each level of care.⁶ These resources include the capability to: provide screening and counseling for healthy dietary and exercise habits; screen, counsel, and provide cessation opportunities for smokers; and recognize and screen patients at high-risk for vascular conditions (Table I).

Additionally, early identification of patients at risk of deep vein thrombosis (e.g. hospitalized, injured, and post-surgical patients), compartment syndrome, and blunt cerebrovascular injury requires few resources but adds significant value to vascular care (Table I). Blunt cerebrovascular injury should be assessed, at least clinically, at first-level hospitals; higher levels of care should consider diagnostic imaging, if available.

Many LMICs have high rates of HIV infection. HIV-associated vascular disease and side-effects of anti-retroviral therapy (e.g. metabolic syndrome) place an additional burden of vascular conditions on populations who are not otherwise at high-risk of vascular disease.⁴¹ Active screening and counseling are important for at-risk patients. Given the decentralized platforms of HIV care in LMICs, these capabilities are essential at all levels of care (Table I).

All levels of care should have protocols that direct timely triage and treatment or transfer of patients with emergency conditions; these protocols should include emergency vascular conditions (e.g., vascular injury, acute limb ischemia) (Table I). Further, facilities should have a referral mechanism for patients with non-emergency vascular conditions who require more advanced services.

Diagnostics

As an extension to the vascular physical exam, the capability to perform and interpret an ankle-brachial index is essential at the first-level hospital (Table II).

Many first-level and referral hospitals in LMICs do not have an ultrasound machine.⁴² However, this technology is becoming available more commonly.²¹ Therefore, the capability for first-level and referral hospital providers to use an ultrasound to diagnose deep venous thrombosis is desirable (Table II). Arterial duplex capabilities (including carotid duplex) are beyond the scope of most first-level hospitals. The capability for clinicians and/or technicians to perform and interpret these studies is essential at the tertiary level.

Glucose testing is essential at all levels of care (Table II). Early identification and secondary prevention of diabetes mellitus is vital to the prevention of vascular complications.⁴³ Hemoglobin determination and blood typing and crossmatching are essential at the first-level hospital. Most other laboratory capabilities are desirable at this level, but essential at the referral hospital level (e.g. chemistry, coagulation profile, blood and tissue culture). The value added to numerous conditions by improving laboratory capabilities at the first-level hospital should be considered if resources permit.⁴⁴

Medical care

Counseling, recognition of, and multi-drug therapy for patients at medium- to high-risk of vascular disease is cost-effective and essential at the first-level hospital (e.g. aspirin, calcium-channel or beta receptor blocker, angiotensin-converting-enzyme inhibitor, and a statin) (Table III).⁴⁵

The combination of an increasing prevalence of diabetes and vascular disease is causing an epidemic of lower-extremity wounds.⁴³ Thus, non-operative wound care and appropriate documentation over time, which is low-cost and requires minimal training, is essential for all levels of care (Table III). Given its low-cost and proven effectiveness, physiotherapy for cardiovascular health and/or claudication is essential at the first-level hospital.⁴⁶

Emergency conditions that can be treated effectively with low-cost resources should be managed at the first-level hospital to avoid preventable death.³⁷ Thus, blood transfusion capability for the management of vascular injuries is essential at the first-level hospital (Table III).

Complete decongestive therapy for lymphedema is essential at the tertiary hospital level (Table 3). However, in countries with endemic filariasis, this capability might be considered essential at lower levels of care to complement more less intensive therapies.

Anti-coagulation therapy and a warfarin monitoring system are essential at the referral hospital level (Table III). First-level hospitals that care for a large number of patients in need of anti-coagulation may consider making the requisite resources essential.

Surgical care

Basic interventions to control life-threatening hemorrhage, such as external direct pressure and appropriate tourniquet application and time keeping, are essential at all levels of care (Table IV). It should be noted that pre-hospital tourniquet use in areas where delays to surgical care are prevalent can save lives, but can also result in limb loss, untoward consequences of prolonged limb ischemia, and death if inappropriately applied.⁴⁷ These potential problems may be less of a concern in hospitals that can quickly evaluate and control bleeding after tourniquet application.⁴⁸ Nonetheless, tourniquet use in all settings requires special training.⁴⁹

More complex, life-saving surgical interventions (e.g. damage control shunting, fasciotomy, damage control amputation, vascular repair) are essential at first-level hospitals given the consequences of expected delays in transfer to higher levels of care in many LMICs.⁵⁰ However, these procedures require moderate skill and should only be performed at well-functioning hospitals with a surgeon or at least an experienced non-surgeon available. For procedures that are beyond the scope of the first-level hospital, particularly those that are not emergencies, patients should be referred to a skilled surgical care provider (e.g. peripheral bypass, surgical management of venous insufficiency) and a facility capable of caring for the complications that may be encountered.

As with decongestive therapy, surgical management of lymphedema at the tertiary level is essential in areas that continue to have endemic filariasis (Table IV).⁵¹ Negative pressure wound management provides significant benefits to patients with open wounds, particularly when reconstructive options are not available.⁵² These systems can be improvised and made low-cost.⁵³ Thus, they are essential at the referral hospital level, though could readily be made essential at the first-level hospital if resources allowed.

Equipment and supplies

The recommendations for essential equipment and supplies follow the recommendations above (Table V). Handheld Doppler devices are used in the maternity wards of many first-level hospitals in LMICs; they are also essential for vascular examination at that level.

Fogarty balloons and synthetic graft material are expensive and require some degree of vascular surgical training. The former is essential at tertiary level, given its broader benefits to surgical care (e.g. biliary duct exploration); the latter is desirable and should only be made available to providers trained in their use (Table V).

Similarly, advanced imaging equipment and supplies associated with angiography are desirable at higher levels of care, but could be made available for use by skilled providers if the need was present and resources allowed. However, a simplified angiography technique using an X-ray machine at a first-level hospital has been described;⁵⁴ the resources for this technique might be considered desirable at a well-functioning first-level hospital with an experienced surgical care provider.

Medications

The WHO offers model lists of essential medications, including those for the management of hypertension, diabetes, and dyslipidemia.⁵⁵ Thus, the current recommendations do not include the numerous medications essential for cardiovascular care. However, several vascular care medications are highlighted (Table VI). Aspirin and ivermectin in areas with endemic filariasis are essential at the primary health center. Unfractionated heparin and/or generic low-molecular weight heparin, protamine, vitamin K, and a statin are essential at the first-level hospital. Warfarin should only be available to facilities capable of anticoagulation monitoring.

Discussion

This study provides consensus recommendations on essential vascular care functions and resources for LMIC healthcare systems. These recommendations might serve as useful guidelines for planning and organizing vascular care in some LMICs, if resources permit. LMICs that are currently struggling to meet the needs of health problems that comprise a larger health burden than vascular conditions (e.g. malnutrition, non-vascular trauma, poor maternal and child health) can use these recommendations while planning to prevent vascular conditions and meet future vascular care needs. Before considering the fitness of these recommendations, healthcare systems must assess the vascular care needs of their population through population-based studies of vascular conditions and facility-based

registries.^{13,56} Once the need to improve vascular care is established, these recommendations can be considered.

It is important to note that these recommendations only consider the essential and desirable inputs (i.e. structure) for vascular care. Inputs alone are insufficient for producing successful outcomes.⁵⁷ Healthcare systems must create and sustain evidence-based processes that improve vascular outcomes. These processes require ongoing monitoring, evaluation, and feedback to ensure they are successful. Potential monitoring points include health service delivery indicators (e.g. proportion of patients counseled regarding cardiovascular risk factors), sentinel events (e.g. death due to lack of external hemorrhage control) and meaningful outcomes (e.g. amputation rate among patients with lower extremity diabetic foot lesion).

While much can be done to improve vascular care at first-level hospitals, LMIC healthcare systems rely heavily on higher levels of care.⁵⁰ In such settings, ensuring that first-level hospital providers can recognize a condition that requires more advanced care and stabilize and transfer patients to a capable facility is imperative.⁵⁸ For example, patients with a major vascular injury require triage, early diagnosis, temporary hemorrhage control, and transfer to a hospital with a surgeon capable of performing vascular surgical techniques. To avert preventable death and disability, healthcare systems must ensure that vascular conditions are included in referral protocols, that efficient and safe inter-hospital transfer systems are in place, and that vascular emergencies are covered by national health insurance schemes to facilitate care.

Successful decentralized surgical care relies on the knowledge and skills of first-level hospital providers and the resources afforded to them.⁵⁹ These providers are often non-surgeons or non-physicians with little to no vascular surgical training. While these providers are valuable for patients with common conditions that require moderate skill to treat effectively (e.g. amputation for lower extremity gangrene), they may be less valuable for patients with complex surgical conditions, including those that require advanced vascular surgery (e.g. late stage peripheral vascular disease). Thus, surgeons trained specifically in vascular surgical techniques should be available in locations with the equipment and supplies to provide this type of care. It has been well documented that regional vascular care centers in high-income countries provide better outcomes than other hospitals given their volume and specifically designed processes to care for patients with vascular conditions and other co-morbidities.⁶⁰ It is worth evaluating similar models in LMICs to determine if regionalized systems should be developed to improve outcomes given the differences in pre-hospital care capacity and the quality of patient stabilization prior to and during inter-hospital transfer between high-income countries and LMICs.

Lastly, technical, nursing, medical, and surgical education in LMICs has focused on training providers to manage infectious diseases and ensure maternal and child health.^{61,62} Given the increasing burdens of injury and vascular conditions, the education systems and task-sharing programs must adapt their curriculum to the needs of the population.^{63–65} In addition, continuing vascular care education of existing providers should be incorporated into graduate and other levels of training modules.

Conclusion

These recommendations have the potential to improve LMIC healthcare systems' ability to respond to the large and growing burden of vascular conditions. Many of these resources can be provided with thoughtful planning and organization without significant increases in cost. However, the resources must be incorporated into a system that includes surveillance of vascular conditions, monitoring and evaluation of vascular capacity and care, a well functioning pre- and inter-hospital care and transport system, and vascular training for both existing and future healthcare workers.

Acknowledgments

This study was funded, in part, by grants R25-TW009345 and D43-TW007267 from the Fogarty International Center, US National Institutes of Health. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

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Appendix

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Table I

Prevention, screening, counseling, and examination

| Screening, counseling and evaluation | Facility level | | | |
|--|----------------|-----------------|--------------|--------------|
| | PH C | First- level | Referr al | Tertia ry |
| Dietary screening and counseling | E | E | E | E |
| Exercise screening and counseling | E | E | E | E |
| Smoking screening and counseling | E | E | E | E |
| Smoking cessation opportunities | E | E | E | E |
| Blood pressure measurement | E | E | E | E |
| Recognize and screen patients at high-risk for vascular disease | E | E | E | E |
| Take vascular history and physical exam | E | E | E | E |
| Prevent, recognize and evaluate diabetic foot lesion in a diabetic | E | E | E | E |
| DVT risk-assessment and evaluation | D | E | E | E |
| Recognize and evaluate possible compartment syndrome | E | E | E | E |
| Blunt cerebrovascular injury evaluation | D | E | E | E |
| HIV- and HAART-related vascular disease screening and counseling* | E | E | E | E |
| Protocols for timely triage and treatment or transfer of vascular conditions | E | E | E | E |

PHC – primary health center; DVT – deep vein thrombosis; HIV – human immunodeficiency virus; HAART – highly active anti-retroviral therapy; PHC – outpatient clinics, staffed by non-physicians; First-level hospital – typically staffed by general practitioners, may or may not provide surgical services; Referral hospital – typically staffed by specialists, usually including a general surgeon; Tertiary hospital – offer a wider range of specialists, and laboratory and imaging capabilities; Resource designation at a particular level: E – essential; D – desirable; I – irrelevant (not considered to be available at the particular level even with full resource availability);

* Essential when the local epidemiology warrants.

Table II

Diagnostics

| Diagnostics | Facility level | | | |
|--|----------------|-----------------|--------------|--------------|
| | PH C | First- level | Referr al | Tertia ry |
| Ankle-brachial index | D | E | E | E |
| Exercise ankle-brachial index | I | D | E | E |
| Venous compression and duplex ultrasonography to evaluate for DVT | I | D | D | E |
| Peripheral and central arterial duplex ultrasonography | I | I | D | E |
| Carotid duplex ultrasonography | I | I | D | E |
| Clinician interpretation of arterial duplex ultrasonography | I | I | D | E |
| Technician/radiologist interpretation of arterial duplex ultrasonography | I | I | D | E |
| Point-of-care and/or glucose testing | E | E | E | E |
| Hemoglobin | I | E | E | E |
| Complete blood count | I | D | E | E |
| Creatinine | I | D | E | E |
| Chemistry | I | D | E | E |
| Coagulation profile | I | D | E | E |
| Type and cross-match for blood and blood products | I | E | E | E |
| Lipid profile | I | D | D | E |
| Hemoglobin A1c | I | D | D | E |
| Syphilis assay for vasculitis/aortitis (e.g. VDRL) | I | E | E | E |
| Hypercoagulability evaluation (e.g. fibrinogen, factor assays, etc.) | I | I | D | D |
| Blood and/or tissue culture | I | D | E | E |
| Gram stain | I | D | E | E |

PHC – primary health center; DVT – deep vein thrombosis; PHC – outpatient clinics, staffed by non-physicians; First-level hospital – typically staffed by general practitioners, may or may not provide surgical services; Referral hospital – typically staffed by specialists, usually including a general surgeon; Tertiary hospital – offer a wider range of specialists, and laboratory and imaging capabilities; Resource designation at a particular level: E – essential; D – desirable; I – irrelevant (i.e. resource not considered to be available at the particular level even with full resource availability).

Table III

Medical care

| Medical care | Facility level | | | |
|--|----------------|-----------------|--------------|--------------|
| | PH C | First- level | Referr al | Tertia ry |
| Counseling and multi-drug therapy for patients at high-risk of or with CVD | D | E | E | E |
| Non-operative lower extremity wound care and appropriate documentation | E | E | E | E |
| Ambulation, extremity elevation at rest and compression therapy for DVT | E | E | E | E |
| Physiotherapy for vascular health and/or claudication | D | E | E | E |
| Complete decongestive therapy for lymphedema | D | D | D | E |
| Blood transfusion capabilities | I | E | E | E |
| Anti-coagulation therapy | I | D | E | E |
| Warfarin monitoring system | I | D | E | E |

PHC – primary health center; CVD – cardiovascular disease; DVT – deep vein thrombosis; PHC – outpatient clinics, staffed by non-physicians; First-level hospital – typically staffed by general practitioners, may or may not provide surgical services; Referral hospital – typically staffed by specialists, usually including a general surgeon; Tertiary hospital – offer a wider range of specialists, and laboratory and imaging capabilities; Resource designation at a particular level: E – essential; D – desirable; I – irrelevant (i.e. resource not considered to be available at the particular level even with full resource availability).

Table IV

Surgical care

| Surgical care | Facility level | | | |
|--|----------------|-----------------|--------------|--------------|
| | PH C | First- level | Referr al | Tertia ry |
| External hemorrhage control with direct pressure | E | E | E | E |
| Appropriate tourniquet application and time keeping | E | E | E | E |
| Vessel ligation | I | E | E | E |
| Vascular anastomosis | I | D | E | E |
| Damage control shunting* | I | E | E | E |
| Fasciotomy (all sites)* | I | E | E | E |
| Debridement of mangled extremity | I | E | E | E |
| Local debridement of ulcer | D | E | E | E |
| Exposure and operative management of peripheral vascular Injuries* | I | E | E | E |
| Exposure and operative management of central vascular injuries | I | D | E | E |
| Damage control amputation (e.g., Guillotine, through joint) | I | E | E | E |
| Digital amputation | I | E | E | E |
| Ray amputation | I | D | E | E |
| Trans-metatarsal amputation | I | D | E | E |
| Below-knee amputation* | I | E | E | E |
| Above-knee amputation* | I | E | E | E |
| Non-damage control upper-extremity amputation | I | D | E | E |
| Visceral or peripheral thromboemblectomy* | I | E | E | E |
| Visceral or peripheral endarterectomy | I | I | D | E |
| Vein harvest and grafting* | I | E | E | E |
| Peripheral bypass | I | I | D | E |
| Carotid endarterectomy | I | I | I | E |
| Surgical management of varicose veins and chronic venous insufficiency | I | I | D | E |
| Elective abdominal aortic aneurysm repair | I | I | I | D |
| Arteriovenous fistula or graft for vascular access | I | I | D | D |
| Peritoneal dialysis catheter placement | I | I | D | E |
| Staged subcutaneous excision underneath flaps | I | I | D | D |
| Subcutaneous excision and SSTG resurfacing for chronic lymphedema | I | I | D | D |
| Central venous catheterization | I | D | E | E |
| Arterial pressure monitoring | I | I | D | D |
| Negative pressure wound management | I | D | E | E |

PHC – primary health center; SSTG – split-thickness skin graft; PHC – outpatient clinics, staffed by non-physicians; First-level hospital – typically staffed by general practitioners, may or may not provide surgical services; Referral hospital – typically staffed by specialists, usually including a general surgeon; Tertiary hospital – offer a wider range of specialists, and laboratory and imaging capabilities; Resource designation at a particular level: E – essential; D – desirable; I – irrelevant (i.e. resource not considered to be available at the particular level even with full resource availability);

* Procedure requires moderate skill and should be considered essential only at well-functioning first-level hospitals (and higher levels) where a surgeon or at least a very experienced non-surgeon is available.

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Table V

Equipment and supplies

| Equipment and supplies | Facility level | | | |
|--|----------------|-----------------|--------------|--------------|
| | PH C | First- level | Referr al | Tertiar y |
| Sphygmomanometer | E | E | E | E |
| Tourniquet | E | E | E | E |
| Hand-held Doppler | I | E | E | E |
| Fogarty balloons of standardized sizes (e.g. 3, 4 and 6) * | I | E | E | E |
| Ultrasound with vascular probe and duplex capabilities | I | D | D | E |
| Basic synthetic graft selection | I | I | D | D |
| Advanced synthetic graft selection | I | I | D | E |
| Standardized minor vascular tray | I | E | E | E |
| Standardized major vascular tray | I | D | E | E |
| C-arm fluoroscopy | I | I | D | D |
| Angiography * | I | D | D | D |
| Surgical loupes (simple, small magnification lens) | I | D | D | E |
| Polypropylene double-armed tapered suture (e.g. sizes 2-0 - 7-0) | I | D | E | E |

PHC – primary health center; outpatient clinics, staffed by non-physicians; First-level hospital – typically staffed by general practitioners, may or may not provide surgical services; Referral hospital – typically staffed by specialists, usually including a general surgeon; Tertiary hospital – offer a wider range of specialists, and laboratory and imaging capabilities; Resource designation at a particular level: E – essential; D – desirable; I – irrelevant (i.e. resource not considered to be available at the particular level even with full resource availability).

* Resource use requires moderate skill and should be considered essential only at well-functioning first-level hospitals (and higher levels) where a surgeon or at least a very experienced non-surgeon is available.

Table VI**Medications**

| Medications | Facility level | | | |
|------------------------------|-----------------------|--------------------|-----------------|-----------------|
| | PHC | First-level | Referral | Tertiary |
| Aspirin | E | E | E | E |
| Unfractionated heparin | I | E | E | E |
| Low-molecular weight heparin | I | E | E | E |
| Protamine | I | E | E | E |
| Benzopyrones (e.g. coumarin) | I | I | D | E |
| Warfarin | I | D | E | E |
| Vitamin K | I | E | E | E |
| Statin | D | E | E | E |
| Ivermectin | E | E | E | E |

PHC – primary health center; outpatient clinics, staffed by non-physicians; First-level hospital – typically staffed by general practitioners, may or may not provide surgical services; Referral hospital – typically staffed by specialists, usually including a general surgeon; Tertiary hospital – offer a wider range of specialists, and laboratory and imaging capabilities; Resource designation at a particular level: E – essential; D – desirable; I – irrelevant (i.e. resource not considered to be available at the particular level even with full resource availability);

* Essential when the local epidemiology warrants.