Leech therapy (Jalaukavacharana) - A gift of ayurveda for treatment of medico-surgical diseases

Saxena Varsha¹, Srivastava Niraj²*, Kumar Pradeep³
¹Department of Shalya-Tantra, Main campus, Uttarakhand Ayurveda University (UAU), Dehradun, Uttarakhand, India
²Department of Kaumarbhritya / Bal-Roga, Sardar Patel Institute of Ayurvedic Medical Sciences & Research Centre. Lucknow, Uttar Pradesh. Pin code- 226002, India
³Department of Shalya-Tantra, Faculty of Ayurveda, Institute of medical sciences Banaras Hindu University, Varanasi (U.P), India

Article History:
Received on: 24 Apr 2020
Revised on: 26 May 2020
Accepted on: 27 May 2020

Keywords:
Jalaukavacharana, Leech therapy, Hirudin, Abscess, Deep vein thrombosis (DVT)

The first description of Jalaukavacharana (leech therapy) is available in Sushruta Samhita written in 800 B.C. Recently, many pieces of research have proved that leech saliva has a variety of bioactive compounds including anti-thrombin (Hirudin, bufrudin), antiplatelet (calin), antiplatelet (calin), factor Xa inhibitors, antibacterial and other property. The main objective of the present article is to explore the procedures of leech therapy and research works done over a few decades on the application of leech therapy in different medico-surgical diseases. The procedure of leech therapy is documented from authors' observations and information, and its application in different diseases is gathered from various published works of the last ten years. Many clinical pieces of research show that leech therapy is beneficial in various medico-surgical diseases. A total of eight publications were included in the final selection after systematic analysis. Leech therapy or Jalaukavacharan is an ancient Ayurvedic bloodletting technique that has the great potential to manage many inflammatory, ischemic, and infectious diseases. Leech’s saliva contains many biologically and pharmacologically active compounds that exert anticoagulant, antiplatelet, anti-inflammatory, and anti-edema effects in the host’s body. Arthritis, venous congestion, vascular diseases, abscess, ischemic heart disease, etc. can be successfully managed by leech therapy.

INTRODUCTION

Ayurveda is a system of medicine with historical roots in the Indian subcontinent and has been practised around 6,000 years ago. Leech therapy (Jalaukavacharana) has been used to treat various diseases through Raktmokshan, a para surgical procedure in the surgical stream of Ayurveda. Leech sucks only impure blood. So, leech therapy is considered as blood purification therapy. Sushruta Samhita is the treatise of surgery in which “Jalaukavacharniya” is one of its chapters. Everything about Jalauka and its application has been scientifically described (Yadavji and Acharya, 2009a). Jalaukavacharana forms by the addition of two words: Jalauka and Avacharana. Jalaukavacharana
means the application of Leeches. The name ‘leech’ is derived from “laece,” an old English word for physician (Davis and Appel, 1979; Irish et al., 2000). The therapeutic application of Leech is practiced among the other system of medicine, such as in Unani and Siddha also (Periyasami et al., 2018). Leeches were named Hirudo medicinalis in 1758 by Linnaeus (Mory et al., 2000). Jalauka (Leech) is a segmented worm of Phylum Annelida. Leech is found in high quality in freshwater ponds of India (Vaibhava et al., 2016). The treatment of disease with medicinal leeches is also known as Hirudotherapy (H.T.) (Whitaker et al., 2003).

In Modern medical sciences, leech therapy began in the 1960s, because of the practical results in plastic and reconstructive surgery for postoperative venous congestion and graft rejections treatment. The bio-active substances found in Leech’s saliva, commonly known as “Hirudo substances” are also called Salivary Glands Secretion (SGS). Salivary Glands Secretion (Saliva) contains more than 120 bioactive substances, potent anticoagulant, vasodilator anesthetic, bacteriostatic, anti-inflammatory, and analgesic properties; some of them are still being examined. Haycraft (1984) discovered “hirudin,” which is the most important component (Field, 1991). Leech should be removed when the patient feels pricking pain and itching over the bite because initially, leeches suck the impure blood then the pure.

**Aim**

The article aims to review and discuss leech therapy, its procedures, and research works done over a few decades in the field of leech application in different diseases.

**Indication of leech therapy**

In Ayurveda, Jalaukavacharan is shown to have effects in delicate or weak patients, female patients, old aged, or too young patients suffering from Rakta-Pradoshaj Vikaras (blood originated diseases) (Singh and Rajoria, 2019). Jalauka (Leeches) is Sheeta in nature, and so, it is usually applicable in Pittaj and Raktaj viharas (disorders). Jalaukavacharan is very useful in Vidradhi (abscess), Visarpa (inflammatory skin disorders), Gula (inflammatory condition of the abdomen), Pidika, Kushta, Charmandala (skin diseases), etc. (Pandey, 2006).

Leech therapy is widely used in modern medicine for treating a variety of challenging medical and surgical conditions such as plastic surgery (Henderson et al., 1983), Arthritis (Osteoarthritis and Rheumatoid Arthritis) (Ahmad and Anwar, 2009), Venous congestion (Weinfeld et al., 2000), Vascular diseases (Pospelova and Barnaulov, 2010), Thrombophlebitis, etc.

**Contraindication of Leech therapy**

In Ayurveda, Leech therapy is contraindicated in Pandu Rogi (Anemic patient), Sarvanga Sotha (generalized oedema), Udara Rogi (individuals suffer from gastrointestinal tract disorders), Shosha Rogi (cachexia patient) and Garbhini (pregnant women) (Yadavji and Acharya, 2009b). Leech therapy is contraindicated in HIV patients or who take immunosuppressive drugs, Hemorrhagic diseases, Hypotension, Hypotonia, Absolute Hemophilia, Pregnancies, Severe Anemia (<5g/dl) and Allergy to Leech (Stange et al., 2012).

**METHODOLOGY**

**Material Required for Leech therapy**

1. Two small glass jars, kidney tray, one big bowl. Figure 1.
2. Sterilised gauze, swab, and gloves
3. Sterile needle, sterile dispovan syringe (10 ml)
4. Savlon and dressing material.
5. Turmeric powder

**METHOD OF JALAUKAVACHARANA (LEECH THERAPY)**

Method of leech therapy completed in three steps

**Purva Karma (Pre-Procedure Protocols)**

In Purvakarma, mainly Snehana (oleation) and Swedana (sudation) of the patient is done and cleaning of part of the body to which Leech is going to be applied. For leeches to suck the maximum amount of blood very quickly without any problem, they must be stimulated and energized. This is done by using the paste of mustard and turmeric powder on the body of Leech or drop leeches in the water containing turmeric powder, and it is found that an inactive leech becomes active Figure 2.

**Pradhana Karma (Main Procedure Protocols)**

Main procedures are completed in the following steps-

1. Before the application of leeches, the patient’s affected part is cleaned and sterilised with boiled warm water.
2. First, Shodhita (Clean) of the leeches is done by putting them in turmeric mixed water for 15 minutes and keep in plain water for 5 minutes.
3. Then adequate numbers of leeches applied to the area of maximal congestion one by one Figure 3.
4. Once the leeches are positioned, it will remain safely in place until fully distended and then detaches spontaneously. (30-50 mm.)
5. The blood is allowed to ooze out for 20-25 minutes.
6. Leeches should again be placed on the patient every 4th day or as required.
7. So a maximum of five times leeches may be placed to a single patient.
8. The wound dressing is done with Haridra (Curcuma longa) powder.

**Paschatya-Karma (Post-Procedural Protocols)**
1. The leech/leeches fall away after drawing blood (Jaluakas), and when leeches fall apart, its body should be massaged with rice powder, and its mouth should be massaged with oil and salt and gently squeezed till signs of proper vomiting appear Figure 4.
2. The properly vomited one should be placed as before in glass jar.
3. The water of glass jar should be chlorinated and replaced after six days.

**Amount of blood sucked by Leech**
1. In-person who is reliable has an excellent accumulation of Doshas and has suitable age (more than 16 and less than 70 years of age) after Vaman, Virechana, one Prastha (Thirteen and a half pal i.e., 540 ml) of blood may be allowed to flow out.
2. For calculating the amount of blood sucked, leeches should be weighed before and after application.

**Bite of the Leech during leech therapy**

After detachment of Leech, it leaves the “Y” shape bite mark on the skin surface with its smaller anterior sucker Figure 5. The leech saliva is filled with a chemical that contains a painkiller and Anesthetics substance, which stops you from feeling the bite. (Michalsen et al., 2007).

**OBSERVATION AND RESULT**

Various published articles on “application of leech therapy (Jaluakavacharana) on various diseases” and “Hirudotherapy (H.T.) in various diseases” were studied and analyzed according to the aim of the study. A total of eight publications was included in the final selection after systematic analysis. Medicinal Leech is a small “factory” manufacturing many biologically active substances. Leech saliva contains more than 120 compounds that exert positive effects in the host’s body Table 1.

**Leech therapy in Deep vein thrombosis**

Deep vein thrombosis (DVT) is a semisolid clot in the vein, which has more chance to develop pulmonary embolism due to thrombosis formation in the calf muscle (Das, 2016). Leech therapy is very effective in DVT because the saliva of Leech contains many bio-active substances like Hirudin/Hirudin, calin, factor Xa inhibitor, which hampers the coagulation of blood. Leech dissolves clots of blood by its thrombolytic effect. Leech saliva contains three compounds that act as a vasodilator agent like Acetylcholine etc. The saliva of leeches also includes an aesthetic substance. All compounds work together to decrease blood viscosity, making a thinner consistency of blood to promote better flow (Kaur et al., 2015).

**Leech therapy in Non-healing ulcer**

Leech saliva provides Carboxypeptidase that is an inhibitor enzyme to cure ulcer area, which reduces vascular congestion. Leech saliva has Histamine like substances and Acetylcholine like substances. These substances act as peripheral vasodilator effects, improves blood circulation, and manage ischemia around the wound, thus promotes wound healing (Neelofer et al., 2018).

**Leech therapy in Abscess (Vidradhi)**

*Vidradhi* is a clinical condition that can spread inflammation of skin & subcutaneous tissue. In the modern system of medicine, there is no alternative to antibiotic and anti-inflammatory drugs to manage inflammation. Some leech saliva compounds such as Bdellin, etc. have an anti-inflammatory effect which inhibits trypsin, plasmin, and acrosin (Eldor et al., 1996). Ayurveda says that the *Jalaukavacharana* mode of action is effective in managing inflammation due to its capacity to remove Rakta Dhatu and Pitta Doshas.

**Leech therapy in Micro-vascular & Reconstructive Surgery**

Micro-vascular reconstructive surgery involves the relocation of autogenously vascularised tissues to renovate extensive tissue defects. It has been used by different specialists today, like plastic surgery, gynecological surgery, general surgery, ophthalmoscopy surgery, neurosurgery, etc. Leeches are used to reduce the congestion by removing blood that can’t exit via the venous system (Mutimer et al., 1987) Leeches are also used in skin flap transplantsations, which help inadequate blood supply to the flap and healing process of the skin graft (Deganc
Figure 1: Material required in Leech therapy

Figure 2: Purva Karma (Pre-procedure) in Leech therapy

Figure 3: Pradhan Karma (Main-Procedure) in Leech therapy

Figure 4: Paschata Karma (Post-Procedure) in Leech therapy
Table 1: Components of Leech saliva that exert effects in the host’s body

| Components of Leech saliva | Exert effects in the host’s body |
|----------------------------|----------------------------------|
| Hirudin                    | It is potent anticoagulant (blood thinner) and inhibits blood coagulation by binding to thrombin. ([Eldor et al., 1996](#)) |
| Calin                      | Calin mainly blocks the binding of the Von Willebrand factor to collagen; thus, it is conducive to inhibit blood coagulation. ([Munro et al., 1991](#)) |
| Destabilase                | It will have thrombolytic effects that dissolve fibrin ([Zavalova et al., 2000](#)). |
| Hirustasin                 | It inhibits kallikrein, trypsin, and chymotrypsin. ([Sawyer, 1986](#)) |
| Hyaluronidase              | Antibiotic property increases the permeability of the host skin (spreading factor) effective in joint pain. ([Adams, 1988](#)) |
| Tryptase inhibitor         | Inhibits mast cells of host ([Eldor et al., 1996](#)). |
| Factor Xa inhibitor        | Suppresses the activity of the Xa coagulation factor and effective in the treatment of joint disorders such as Osteoarthritis and Rheumatoid arthritis. ([Hofmann et al., 1992](#)). |
| Carboxypeptidase’ A inhibitors | Increases in the inflow of blood at the bite site ([Reverter et al., 1998](#)). |
| Histamine like substances  | Vasodilator activity ([Kumar and Prakash, 2011](#)). |
| Acetylcholine              | Vasodilator activity ([Zaidi et al., 2011](#)). |
| Anesthetics substance      | Some anesthetic substances available in leech saliva are equally potent to morphine and reduce pain during bite ([Rigbi et al., 1987](#)). |
Leech therapy in arthritis

In the saliva of Leech, several components are available which have an anti-inflammatory effect, anesthetic effect, and vasodilator effect, which are needed for the treatment of arthritis. Anti-inflammatory compounds are bdelins and eglins (Abdullah et al., 2012), and vasodilator compounds are histamine-like substances and Acetylcholine that have an essential role during the treatment of Osteo-arthritis and Rheumatoid arthritis. Vasodilator compounds help to dilate the vessels and increase blood flow, consequently removing compounds from the site, relieving pain, and inflammation. So Leech is instrumental in osteoarthritis and rheumatoid arthritis (Eldor et al., 1996).

Leech therapy in cardiovascular

Cardiovascular diseases are mainly related to the heart, veins, and arteries. Leech saliva contains and Hirudin, Calin, and thrombin inhibitors, which improve blood flow through anticoagulation, thrombolytic, and antiplatelet activity (Weinfield et al., 2000; Munro et al., 1991). Blood can thicken, which makes it prone to clot formation and an increase in blood pressure individual. These clots can cause a stroke or heart attack. Many studies exposed that Hirudin is more effective than hiraparin in preventing deep venous thrombosis (DVT) and cardio-vascular patients with unstable angina (Ángeles Corral-Rodríguez et al., 2010).

Leech therapy is also useful in some other diseases like Hemorrhoids, Thrombophlebitis (Shirashotha), Hematomas, External ear and chronic ear infections, dental problems, like gingivitis, gingival edema, etc. and Chronic skin diseases, like scabies, psoriasis, eczematous dermatitis, etc. (Abdullah et al., 2012).

The complication of leech therapy

In Ayurveda, no specific complications are mentioned, but some difficulty of Raktamokshana such as Paka (inflammation) and Daha (burning sensation) can occur (Yadavji and Acharya, 2009c), but modern science mentioned many complications after leech therapy such as

1. Excessive bleeding can occur with leech therapy; it can be controlled by applying direct pressure or topical thrombin (Whitaker et al., 2003). Excessive blood loss may necessitate blood transfusion, so patients should be informed of the possibility (Chepeha et al., 2002).

2. A. hydrophila causes the most common infections involving leech therapy, infections with Serratia marcescens, A. sobria, and Vibrio fluvi-alis have been reported (Ardehali et al., 2006). Infections can arise within 2 to 11 days after leech therapy. Consequently, it can result in abscesses and cellulitis, which can finally progress to sepsis (Abdelgabar and Bhowmick, 2003).

CONCLUSION

Jalaukavacharan (Leech therapy) is an ancient Ayurvedic bloodletting technique which has the great potential to manage ischemic, inflammatory, and infective disease by removing the blood in the deep-seated regions. The saliva of Leech contains numerous bioactive constituents which possess analgesic, anti-inflammatory antiseptic & antibacterial property, etc. Leech therapy is useful in the field of plastic surgery, Arthritis (Osteoarthritis and Rheumatoid Arthritis), Venous congestion, Varicose veins, Hemorrhoids vascular diseases, Thrombophlebitis, cellulitis, scatica, inflammatory reactions, blood purification, ischemic heart disease, and hypertension. It is expected to be of paramount importance due to the ease of leech application and minimum side-effect. Leech therapy has Ayurvedic origin, but it is acknowledged by modern medicine due to its effectiveness in healing various kinds of diseases. It is also considered as wonder therapy.

ACKNOWLEDGEMENT

I acknowledged the Uttarakhand Ayurveda University (Main campus), Harrawala, (Dehradun), Uttarakhand, for providing library facility.

Conflict of Interest

The authors declare that they have no conflict of interest and source of support.

Funding Support

None.

REFERENCES

Abdelgabar, A. M., Bhowmick, B. K. 2003. The return of the leech. Int J Clin Pract, 57(2):103–105.

Abdullah, S., Dar, L., Rashid, A., Tewari, A. 2012. Hirudotherapy /Leech therapy: Applications and Indications in Surgery.

Adams, S. L. 1988. The Medicinal Leech. Annals of Internal Medicine, 109(5):399–399.

Ahmad, T., Anwar, M. 2009. Clinical importance of Leech therapy. Indian Journal of Traditional Knowledge, 8(3):443–445.
Ángeles Corral-Rodríguez, M., Macedo-Ribeiro, S., Pereira, P. J. B., Fuentes-Prior, P. 2010. Leech-Derived Thrombin Inhibitors: From Structures to Mechanisms to Clinical Applications. *Journal of Medicinal Chemistry*, 53(10):3847–3861.

Ardehali, B., Hand, K., Nduka, C., Holmes, A., Wood, S. 2006. Delayed leech-borne infection with Aeromonas hydrophila in escharotic flap wound. *Journal of Plastic, Reconstructive & Aesthetic Surgery*, 59(1):94–95.

Chepeha, D. B., Nussenbaum, B., Bradford, C. R., Teknos, T. N. 2002. Leech Therapy for Patients With Surgically Unsalvageable Venous Obstruction After Revascularized Free Tissue Transfer. *Archives of Otolaryngology-Head & Neck Surgery*, 128(8):960–960.

Das, S. 2016. A concise textbook of surgery. pages 1–274. Das publications.

Davis, A., Appel, T. 1979. Bloodletting Instruments in the National Museum of History and Technology. *Smithsonian Studies in History and Technology*, (41):1–103.

Deganc, M., Zdravic, F. 1960. Venous congestion of flaps treated by application of leeches. *British Journal of Plastic Surgery*, 13:187–192.

Eldor, A., Orevi, M., Rigbi, M. 1996. The role of the leech in medical therapeutics. *Blood Reviews*, 10(4):201–209.

Field, W.S. 1991. The history of leeching and hirudin. *Haemostasis*, 21:3–10.

Henderson, H. P., Matti, B., Laing, A. G., Morelli, S., Sully, L. 1983. Avulsion of the scalp treated by microvascular repair: the use of leeches for postoperative decongestion. *British Journal of Plastic Surgery*, 36(2):235–239.

Hofmann, K. J., Nutt, E. M., Dunwiddie, C. T. 1992. Site-directed mutagenesis of the leech-derived factor Xa inhibitor antistasin. Probing of the reactive site. *Biochemical Journal*, 287(3):943–949.

Irish, J. C., Gullane, P. J., Mulholland, S., Neligan, P. C. 2000. Medicinal leech in head and neck reconstruction. *J Otolaryngology*, 29(5):327–332.

Kaur, R., Chhabra, S., Singh, A. 2015. Role of ayurvedic medicine and leech therapy in management of deep vein thrombosis: a case study. *Journal of Biological & Scientific Opinion*, 3(2):87–90.

Kraemer, B., Korber, K., Aquino, T., Engleman, A. 1988. Use of Leeches in Plastic and Reconstructive Surgery: A Review. *Journal of Reconstructive Microsurgery*, 4(05):381–386.

Kumar, S. A., Prakash, S. O. 2011. Analgesic and Anti-inflammatory activity of leech therapy in the management of arthritis. *International Research Journal of Pharmacy (IRJP)*, 2:172–174.

Michalsen, A., Roth, M., Dobos, G. 2007. Medicinal Leech Therapy. Thieme.

Mory, R. N., Mindell, D., Bloom, D. A. 2000. The Leech and the Physician: Biology, Etymology, and Medical Practice with Hirudinea medicinalis. *World Journal of Surgery*, 24(7):878–883.

Munro, R., Jones, C. P., Sawyer, R. T. 1991. Calin??a platelet adhesion inhibitor from the saliva of the medicinal leech. *Blood Coagulation & Fibrinolysis*, 2(1):179–184.

Mutimer, K. L., Banis, J. C., Upton, J., Upton, J. 1987. Microsurgical Reattachment of Totally Amputated Ears. *Plastic and Reconstructive Surgery*, 79(4):535–540.

Neelofar, K. Z., Khan, F. S., Sherani 2018. Leech therapy In Non-Healing Ulcer - a Case Study. *International Journal of Medical Science and Innovative Research (IJMSIR)*, pages 69–74.

Pandey, G. 2006. Kashinath Sastri Vidhyotini Hindi commentator of Caraka Samhita of Agnivesa- 1st volume. *Sutra Sthana Viddhishtonitama Adhayay chapter*, pages 444–445.

Periyasami, K., Aarthry, M., Monika, N. J., Muthukumar 2018. Attai Vidal (Leech Therapy) in Siddha System of Medicine and Their Current Concept in Therapeutic Application - A Review. *International Journal of Ayurveda and Pharma Research*, 6(5):48–53.

Pospelova, M. L., Barnaulov, O. D. 2010. Hirudotherapy in the treatment of bilateral internal carotid artery occlusion: Case report. *Curr Top Neurol Psychiatr Relat Discip*, 18:51–53.

Reverter, D., Vendrell, J., Canals, F., Horstmann, J., Avilés, F. X., Fritz, H., Sommerhoff, C. P. 1998. A Carboxypeptidase Inhibitor from the Medical Leech Hirudo medicinalis. *Journal of Biological Chemistry*, 273(49):32927–32933.

Rigbi, M., Levy, H., Iraqi, F., Teitelbaum, M., Orevi, M., Alajoutsijärvi, A., Horovitz, A., Galun, R. 1987. The saliva of the medicinal leech Hirudo medicinalis—1. Biochemical characterization of the high molecular weight fraction. *Comparative Biochemistry and Physiology Part B: Comparative Biochemistry*, 87(3):567–573.

Sawyer, R. T. 1986. Feeding biology, ecology, and systematics. volume II. Oxford Science Publications.

Singh, S. K., Rajoria, K. 2019. Medical leech therapy in Ayurveda and biomedicine – A Review. *Journal of Ayurveda and Integrative Medicine*. 
Srivastava Niraj et al., Int. J. Res. Pharm. Sci., 2020, 11(3), 4742-4749

Stange, R., Moser, C., Hopfenmueller, W., Mansmann, U., Buhring, M., Uehleke, B. 2012. Randomised controlled trial with medical leeches for osteoarthritis of the knee. Complementary Therapies in Medicine, 20(1-2):1–7.

Vaibhava, A., Antiwal, M., Singh, J., &amp; O Singh 2016. Leech Therapy (Jalaukavacharana) in Ayurveda: A Scientific Review.Human Journals, 6(4):503–517.

Weinfeld, A. B., Yuksel, E., Boutros, S., Gura, D. H., Akyurek, M., Friedman, J. D. 2000. Clinical and Scientific Considerations in Leech Therapy for the Management of Acute Venous Congestion: An Updated Review. Annals of Plastic Surgery, 45(2):207–212.

Whitaker, I. S., Elmiyeh, B., Wright, D. J. 2003. Hirudo medicinalis: The Need for Prophylactic Antibiotics. Plastic and Reconstructive Surgery, 112(4):1185–1186.

Yadavji, T. V., Acharya 2009a. Shri Dalhanacharaya Nibandhasamgraha commentarator of Sushruta Samhita. Sutra Sthan Jalokavacharniyo Adhayay chapter, pages 45–45.

Yadavji, T. V., Acharya 2009b. Shri Dalhanacharaya Nibandhasamgraha commentarator of Sushruta Samhita. Sutra Sthan Shonitavarniyam Adhayay chapter, 25:53–53.

Yadavji, T. V., Acharya 2009c. Shri Dalhanacharaya Nibandhasamgraha commentarator of Sushruta Samhita. Sutra Sthan Shonitavarniyam Adhayay chapter, 29:53–53.

Zaidi, S. M., Jameel, S. S., Zaman, F., Jilani, S., Sultan, A., Khan, S. A. 2011. A systematic overview of the medicinal importance of sanguivorous leeches. Alternative Med Rev, 16(1):59–65.

Zavalova, L. L., Baskova, I. P., Lukyanov, S. A., Sass, A. V., Snezhkov, E. V., Akopov, S. B., Artamonova, I. I., Archipova, V. S., Nesmeyanov, V. A., Kozlov, D. G., Benevolensky, S. V., Kiseleva, V. I., Poverenny, A. M., Sverdlov, E. D. 2000. Destabilase from the medicinal leech is a representative of a novel family of lysozymes. Biochimica et Biophysica Acta (BBA) - Protein Structure and Molecular Enzymology, 1478(1):69–77.