ARC SAC SCIENTIFIC REVIEW
Stinger Removal

Questions to be addressed:

For adults and children with honey bee envenomation (P) is one method of stinger removal (I) superior to another method of stinger removal (C) in changing degree of local reaction, pain, incidence of anaphylaxis, need for hospital care or treatments provided (O).

Introduction/Overview:

Honeybees, of the order Hymenoptera, exist worldwide and are essential for the pollination of plants including many food crops. They are found in large colonies and will sting to defend their nests.[1] While it is estimated that from 500-1500 stings are needed to produce fatality from systemic honeybee envenomation, it takes only one sting in a person with a honey bee allergy to produce anaphylaxis.[1] Massive envenomation, enough to result in systemic symptoms is rare, but may occur, particularly with more aggressive Africanized honeybees, which is a hybrid invasive species in the United States (US). However it only takes one sting in a sensitized individual to produce anaphylaxis which may result in death. Anaphylaxis from hymenoptera stings is the leading cause of death from animal venom with 40-50 deaths per year reported in the US, with anaphylaxis to hymenoptera occurring in approximately 0.4-3.0% of the US population.[2] In patients with anaphylaxis respiratory tract obstruction is the leading cause of death followed by vascular collapse.[3]

While many forms of hymenoptera can sting a victim multiple times, a honeybee can only sting a victim once as it has a barbed stinger which acts to prevent removal from the victim once the sting occurs.[1] Following the sting, the barbed stinger prevents easy removal from the skin and as the bee flies off the venom apparatus is typically torn away from the abdomen of the honeybee leaving entire stinging apparatus imbedded within the skin of the victim.[1] In a honeybee, the venom apparatus consists of a venom sac and a bifurcated stinger with a piston-like mechanism that even after displacement from the bee functions independently to continue to pump venom into the wound and further imbed the stinger into the victim.[1]

Traditional first aid recommendations operate on the assumption that venom can be squeezed from this venom sac which could worsen local symptoms, and, therefore, the sac should not be squeezed during the removal of the venom apparatus from the skin. Prior recommendations advise removing the retained venom apparatus by scraping it out with the edge of a dull object to consequently avoid squeezing the venom sac that would theoretically squeeze venom into the wound.[4] Analysis of the bee stinger reveals that it is the muscular movement of the piston mechanism that results in venom flowing into the wound; therefore, the method of removal may not be as important as the rapidity of removal.[1] This scientific review was conducted to determine the most appropriate method for removal of a retained honeybee stinging apparatus in the skin following a sting. Two reviewers independently reviewed titles or abstracts to determine eligibility for inclusion and after a consensus was met, the included studies were reviewed for

quality of evidence and interventions, and outcomes. This scientific review did not evaluate ocular honeybee stings.

Current General Recommendations for hymenoptera stings, published in Red Cross First Aid Manual[4]:

Insect Stings

Most of the time, insect stings are harmless. If the person is allergic, an insect sting can lead to anaphylaxis, a life-threatening condition.

What to Look For

Signals of an insect sting include:

- Presence of a stinger.
- Pain.
- Swelling.
- Signals of an allergic reaction.

What to Do

If someone is stung by an insect:

- Remove any visible stinger. Scrape it away from the skin with a clean fingernail or a plastic card, such as a credit card, or use tweezers (Fig. 6-6). In the case of a bee sting, if you use tweezers, grasp the stinger, not the venom sac.
- Wash the site with soap and water.
- Cover the site and keep it clean.
- Apply a cold pack to the area to reduce pain and swelling.
- Call 9-1-1 if the person has any trouble breathing or for any other signals of anaphylaxis.

FIGURE 6-6 If someone is stung by an insect, scrape the stinger away from the skin with a clean fingernail or a plastic card, such as a credit card.

Search Strategy and Literature Search Performed

Key Words Used

Database – PubMed
Search (bee or bees or honeybee) AND (sting or stinger) and removal
Filters=English 20 hits

Database - OneSearch@IU

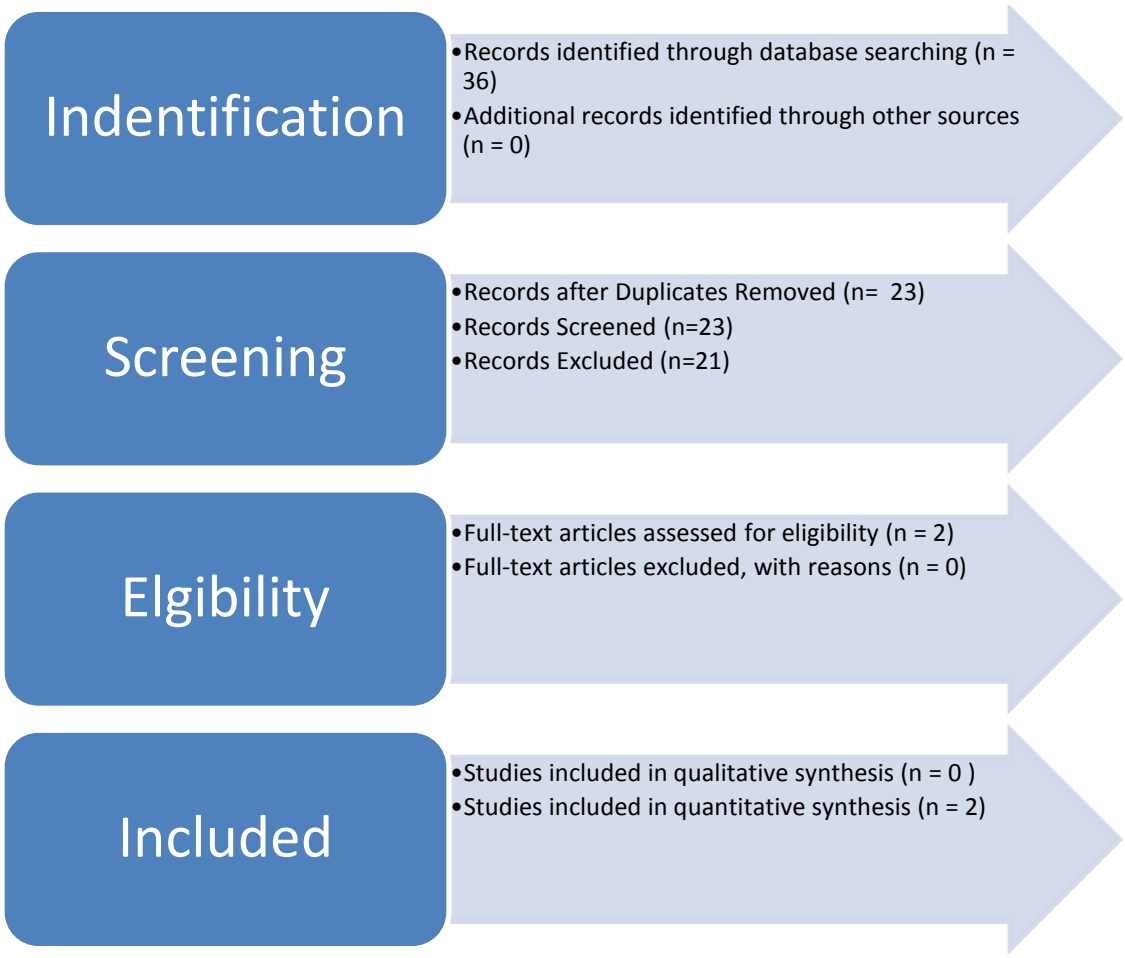
("sting removal" or "stinger removal") AND (bees OR bee OR honeybee* OR apis or hymenoptera) Language=English

Inclusion Criteria (time period, type of articles and journals, language, methodology)
All publication dates; human and animal, all study types, systematic reviews

Exclusion Criteria (only human studies, foreign language, etc…)
English only

Databases Searched and Additional Methods Used (references of articles, texts, contact with authors, etc...)

We searched the following database: PubMed, OVID - EBM Reviews (Cochrane DSR, ACP Journal Club, DARE), GOOGLE Scholar
Additional hand searching was conducted based on review of the articles discovered in the initial search.



Studies included for final review for data analysis:

Title	Author(s)	Journal	Vol	Issue	Page(s)	Year
Rate and quantity of delivery of venom from honeybee stings. J Allergy Clin Immunol. 1994 May;93(5):831-5.	Schumacher MJ, Tveten MS, Egen NB.	J Allergy Clin Immunol	93	5	831-835	1994
Removing bee stings.	Visscher PK, Vetter RS, Camazine S.	Lancet	348	9023	301-302	1996

Scientific Foundation:

Background

Honeybee stings are a common cause of injury in North America, but can also result in mortality's due to both anaphylaxis and massive systemic envenomation. It is unknown how many honeybee stings occur in North America each year, however, the majority of victims only experience local symptoms which includes a raised erythematous area (weal), pain, itching and

swelling. While massive envenomation is a rare cause of mortality, approximately 40-50 deaths per year are recorded in the US due to anaphylaxis from hymenoptera venoms. In sensitized individuals, it takes only one sting to produce anaphylaxis. The risk of systemic reaction, including anaphylaxis, to hymenoptera occurs in approximately 0.4-3.0% of the US population. The mechanism of the honeybee venom apparatus allows for continued penetration of the skin and venom delivery though a piston like mechanism. This increases the amount of venom delivered over time. Traditional first aid practices speculate that grasping the venom apparatus could further introduce venom into the sting, therefore, the stinger apparatus should be scraped out of the wound rather than pulled. There is, however, no clinical data to suggest this theory is true. Instead the piston mechanism that pumps venom into the wound does not appear affected by external pressure, thus it may be the rapidity of stinger removal rather than the mode of stinger removal that dictates the amount of venom deposited.

RESULTS

In **1994, Schumacher et al**[5] (LOE 4) conducted an observational **animal** trial that evaluated the rate of venom delivery from honey bee (*Apis mellifera*) stingers in a rabbit model. In this study, rabbits were anesthetized and after the rabbit's back was shaved, bees were induced to sting the rabbit in this shaved area. Up to 12 stings were induced on each rabbit. Stingers were left in place from 5 seconds to 20 minutes and then removed by grasping the stinger as closely to the skin as possible and pulling it out. The stinger apparatus was then placed on ice to stop contractions. Residual venom was then recovered from each venom sac and assayed for the amount of melittin remaining. In this study an artificial model was also tested. In this model bees were induced to sting absorbent paper, stingers were left in place for various time periods and before and after weights of the absorbent paper was compared to assess venom load. In the rabbit study the venom apparatus was noted to embed progressively deeper over the course of 30 seconds. Ninety percent of the venom was deposited over a period of 20 seconds and no residual melittin was detected in the venom sacs by 40 seconds. Residual venom in the apparatus was inversely related to time ($p>0.05$). The artificial model produced similar results with a significant association between venom delivery and time ($p<0.05$). Venom delivery also appeared to be complete within 30 seconds. This animal study provided very low quality evidence with additional downgrades for bias, indirectness and imprecision. The authors of this study concluded that venom is delivered rapidly from the venom apparatus and that stinger removal would need to be conducted very rapidly in order to prevent significant envenomation.

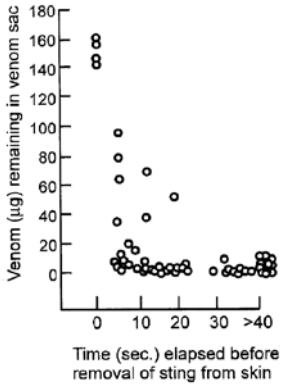


FIG. 2. Decrease of residual venom with time in stings implanted in rabbit skin. Fourteen points are plotted together at greater than 40 seconds.

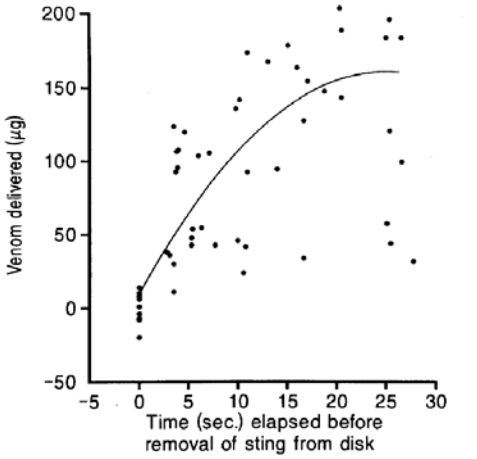


FIG. 3. Dry weight of venom delivered into filter paper disks per unit of time.

TABLE I. Analysis of data shown in Fig. 3, showing distribution of amounts of venom delivered to paper disks at various elapsed times

Elapsed time (sec)	N	Percent of observations in the range (µg)					Median (µg)	Mean ± SD
		<25	25-50	50-100	100-150	>150		
2-7	17	5.9	35.3	23.5	35.3	0	53	71.5 ± 36.7
8-16	12	8.3	16.7	16.7	25.0	33.0	133	114.8 ± 57.6
>16	14	0	21.4	7.1	28.6	42.9	148	141.9 ± 89.2

In **1996**, **Visscher et al**[6] (LOE 2a) published a randomized **human** study evaluating the effects of timing and method of honeybee stinger removal on weal size. In the first part of this study, honeybees were induced to sting a human volunteer on the forearm and stingers were removed at 0.5 seconds, 1 second, 2 seconds, 4 second or 8 seconds. The five sting series was randomized and conducted 5 times on each forearm of the volunteer. After 10 minutes an independent observer, who was blinded, measures the weal size produced by each sting. In the second part of the study honeybees were again induced to sting two volunteers on the forearm and after 2 seconds the volunteers then scraped the stinger apparatus out with the edge of a credit card or removed the stinger apparatus by pinching the stinger between the 1st and second digit and pulling it out. Forearms were alternated and treatment was randomized. Each treatment was conducted 10 times on each of the two volunteers. Weal sizes were again measured and area of each weal was calculated for statistical comparison.

The authors found that there was a significant increase in weal area with increasing time to stinger removal ($p=0.018$) and that weal area was approximately a log-linear function of dose ($p=0.000016$). There was no statistical difference in weal size per method of removal ($p=0.42$) with a mean area in stingers removed by scraping of 80 mm^2 (SE=5.9mm) and removal by pulling 74 mm^2 (SE = 5.1 mm). The authors noted that more stingers broke off in the skin with the scraping method versus the pulling method, where no breakage occurred.

This study provided low quality evidence which was downgraded for bias and imprecision. The authors of this study concluded that the method of honeybee stinger removal does not seem to affect the quantity of venom delivered and that recommendations should emphasize removing the stinger as quickly as possible to minimize the amount of venom delivered.

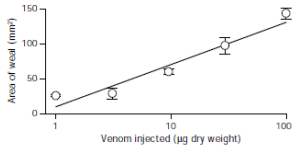


Figure 1: **Dose-response curve of mean sting-weal area (±SE) 10 min after cutaneous injection of venom**

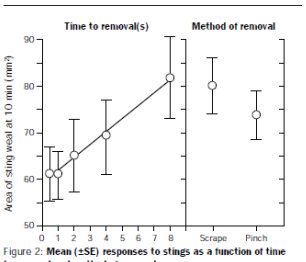


Figure 2: **Mean (±SE) responses to stings as a function of time to removal and method of removal**

Summary of Evidence and Rationale

While the data is limited, evidence suggests that removal of a honeybee stinger as quickly as possible by any method is preferable. Schumacher et al[5] found that in an animal model the venom apparatus embedded progressively deeper over the course of 30 seconds. They also found that residual venom in the apparatus was inversely related to time that 90% of the venom was deposited in 20 seconds and no residual melittin was detected in the venom sacs by 40 seconds. Visscher et al[6] found that the weal times of the local reaction was directly proportional to the amount of time the stinger was in place. They also found that weal size did not vary by method of removal (scraping versus grasping and pulling). It was found that more stingers broke off in the skin with the scraping method than the pulling method.

These studies demonstrate that the rapidity of stinger apparatus removal, rather than the method, is what dictates the amount of venom deposited. Due to the limitations of these studies there are no Standards for treatment recommendations. However, as both studies suggest that the rapidity of stinger apparatus removal, rather than the method, dictates the amount of venom deposited we felt that a Guideline should be rapid removal of the honeybee stinger. Optimally stinger removal should occur within the first few seconds as Visscher demonstrates a significant increase in wheal size over the first 8 seconds. Rapid stinger removal has the potential to limit the size of the local reaction, theoretically limiting pain and potentially other first aid treatments that are needed. A single study suggests that the method removal (grasping and pulling versus scraping it out) is not important when removing the stinger. In addition, there was some suggestion in this same study that grasping and pulling the stinger apparatus rather than trying to scrape it out results in a lower rate of stinger breakage, resulting in a lower rate of retained foreign body. In many instances, particularly in those with short fingernails, pulling the stinger out will be quicker than finding a suitable object for scraping the stinger out. For these reasons we feel that the preferable method of stinger removal is grasping and pulling the stinger out, however, due to the limited data this was included as an Option. No data is available to determine whether or not rapid removal of the stinger would mitigate the risk of anaphylactic reaction in a sensitized individual.

Recommendations:

Standards:

- None

Guidelines:

- Following envenomation by a honeybee, when the stinging apparatus remains imbedded in the skin, remove the stinging apparatus as quickly as possible.

Options:

- It is suggested that the stinger apparatus be removed by grasping and pulling the apparatus versus scraping it out.

Knowledge Gaps and Future Research:

1. Does rapid removal of a honeybee stinger prevent systemic allergic reaction, including anaphylaxis?
2. Following a large number of stings from honeybees does rapid removal of the stingers prevent systemic signs of envenomation?
3. Does one method of stinger removal over another method of stinger removal prevent breakage of the stinger or retention of foreign body.

Implications for ARC Programs:

As current American Red Cross First Aid guidelines state that the remaining stinger apparatus should be scraped out with the dull edge of credit card this will need to be changed to recommend removing the stinging apparatus as quickly as possible, regardless of what method. As it appears that grasping and pulling the stinger apparatus out results in a lower rate of stinger breakage than scraping the stinger out, grasping and pulling appears to be the preferred method of stinger removal. While Africanized bees are considered more aggressive and more likely to result in massive envenomation (including death), stinger morphology and venom components are similar. Therefore these treatment recommendations are applicable to both European and Africanized honeybee stings.

Attach Any Lists, Tables of List of Recommendations Created As Part of This Review

None

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Summary of Key Articles/Literature Found and Level of Evidence/Bibliography:

Author(s)	Full Citation	Summary of Article (provide a brief summary of what the article adds to this review including which question(s) it supports, refutes or is neutral)	Methodology	Bias Assessment	Indirectness/ Imprecision/ Inconsistency	Key results and magnitude of results	Support, Neutral or Oppose Question	Level of Evidence (Using table below)	Quality of study (excellent, good, fair or poor) and why

Schumacher MJ, Tveten MS, Egen NB.	Rate and quantity of delivery of venom from honeybee stings. J Allergy Clin Immunol. 1994 May;93(5):831-5.	Both a rabbit and experimental model that tested the amount of honeybee venom deposition over time. Showed venom deposition directly correlated with length of time stinger apparatus remained in the skin.	Observational	Serious	Not Serious	90% of the venom was deposited over 20 seconds and no residual melittin was detected in the venom sacs by 40 seconds. Residual venom in the apparatus was inversely related to time ($p>0.05$). Significant association between venom delivery and time in artificial model ($p<0.05$).	Support	LOE 4	Fair, this was an animal model that can only be indirectly applied to the question.
Visscher PK, Vetter RS, Camazine S.	Removing bee stings. Lancet. 1996 Aug 3;348(9023):301-2.	Human model of honeybee stinger removal. Weal size	RCT	Serious	Not Serious	Human model of honeybee stinger removal. Weal size	Support	LOE 2a	Good, only 2 subject with multiple stings, subject to

		correlated with time of stinger apparatus in the skin, nod method of removal. Trend towards increased stinger breakage with scraping method.				correlated with time of stinger apparatus in the skin, nod method of removal. Trend towards increased stinger breakage with scraping method.			bias and imprecision.

Additional References (Background, Epidemiology):

1. Int J Dermatol. Bites and stings of medically important venomous arthropods.1998 Jul;37(7):481-96.
2. Vetter RS1, Visscher PK.Casale TB, Burks AW. Clinical practice. Hymenoptera-sting hypersensitivity. N Engl J Med. 2014 Apr 10;370(15):1432-9. doi: 10.1056/NEJMcp1302681.
3. Barnard JH: Studies of 400 Hymenoptera sting deaths in the United States. J Allergy Clin Immunol 1973; 52: pp. 259
4. First Aid/CPR/AED Participant's Manual. American Red Cross. StayWell Health & Saftey Solutions. 2014
5. Schumacher MJ, Tveten MS, Egen NB. Rate and quantity of delivery of venom from honeybee stings. J Allergy Clin Immunol. 1994 May;93(5):831-5.
6. Visscher PK, Vetter RS, Camazine S. Removing bee stings. Lancet. 1996 Aug 3;348(9023):301-2.

Level of Evidence	Definitions (See manuscript for full details)
Level 1a	**Experimental and Population based studies -** population based, randomized prospective studies or meta-analyses of multiple higher evidence studies with substantial effects
Level 1b	**Smaller Experimental and Epidemiological studies -** Large non-population based epidemiological studies or randomized prospective studies with smaller or less significant effects
Level 2a	**Prospective Observational Analytical** - Controlled, non-randomized, cohort studies
Level 2b	**Retrospective/Historical Observational Analytical** - non-randomized, cohort or case-control studies
Level 3a	**Large Descriptive studies** – Cross-section, Ecological, Case series, Case reports
Level 3b	**Small Descriptive studies** – Cross-section, Ecological, Case series, Case reports
Level 4	**Animal studies or mechanical model studies**
Level 5	**Peer-reviewed Articles** - state of the art articles, review articles, organizational statements or guidelines, editorials, or consensus statements
Level 6	**Non-peer reviewed published opinions -** such as textbook statements, official organizational publications, guidelines and policy statements which are not peer reviewed and consensus statements
Level 7	**Rational conjecture** (common sense); common practices accepted before evidence-based guidelines
Level 1-6E	**Extrapolations** from existing data collected for other purposes, theoretical analyses which is on-point with question being asked. Modifier E applied because extrapolated but ranked based on type of study.