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Ilioinguinal and iliohypogastric nerves cannot be selectively blocked by using ultrasound guidance: a volunteer study

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Editor's key points

- Improved technology in ultrasound devices has allowed accurate determination of local anaesthetic spread.
- This study investigates the use of ultrasound in determining local anaesthetic spread and clinical effect for ilioinguinal/iliohypogastric nerve blocks.
- It was not possible to block these nerves separately even using very small volumes of local anaesthetic.
- This has implications for using local anaesthetic nerve blocks to help predict response to neurodestructive techniques.

Background. Ilioinguinal (IL) and iliohypogastric (IH) nerve blocks are used in patients with chronic postherniorrhaphy pain. The present study tested the hypothesis that our method, previously developed in cadavers, blocks the nerves separately and selectively in human volunteers.

Methods. We blocked the IL and the IH nerves in 16 volunteers in a single-blinded randomized cross-over setting under direct ultrasound visualization, by injecting two times the ED_{95} volume of 1% mepivacaine needed to block a peripheral nerve. The anaesthetized skin areas were tested by pinprick and marked on the skin. A digital photo was taken. For further analysis, the parameterized picture data were transformed into a standardized and unified coordinate system to compare and calculate the overlap of the anaesthetized skin areas of the two nerves on each side. An overlap $<$25% was defined as selective block.

Results. Fifty nerve blocks could be analysed. The mean volume injected to block a single nerve was 0.9 ml. Using ultrasound, we observed spread from one nerve to the other in 12% of cases. The overlap of the anaesthetized skin areas of the nerves was 60.3% and did not differ after exclusion of the cases with visible spread of local anaesthetic from one nerve to the other.

Conclusions. The IL and IH nerves cannot be selectively blocked even if volumes below 1 ml are used. The most likely explanation is the spread of local anaesthetic from one nerve to the other, although this could not be directly observed in most cases.

Keywords: chronic pain; ilioinguinal/iliohypogastric; inguinal; nerve block; ultrasonography

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The incidence of chronic pain after inguinal hernia repair affecting daily activities is reported to be 6–11%.[1] Considering the very high number of operations performed, for example, 800 000 in the USA in 2003,[2] this pain syndrome affects the quality of life of many patients potentially with high social costs. Injury to the inguinal nerves is considered to be one of the possible reasons for the development of chronic pain after this surgical procedure.[3] In these cases, surgical revision with neurectomy[4 5] or radiofrequency ablation of the involved nerves [6] may be treatment options in some carefully selected patients.

Ilioinguinal (IL) and iliohypogastric (IH) nerve blocks can be performed to evaluate whether peripheral nociceptive or neuropathic components are present in chronic pain patients after inguinal hernia repair. The result of such blocks may potentially predict which patients will profit by neurectomy or radiofrequency neurolysis. In order to evaluate which nerve is responsible for the pain, a selective block of each nerve would be mandatory. With technical developments in ultrasound devices and transducers in recent years, it is now possible to directly visualize small nerves by ultrasound.[7] We developed an ultrasound-guided double-injection approach with the potential to selectively and separately block the IL and IH nerves in adults.[8] Its accuracy and selectivity has been proved by injecting a small amount of dye in human cadavers and verification of the selective colouring of the nerves by anatomical dissection, but its use to guide a selective block in a clinical setting has not yet been studied.

This study tested the hypothesis that the IL and IH nerves can be blocked selectively and separately in healthy volunteers by injecting a very small volume of local anaesthetic close to each of the nerves. Using a randomized cross-over design, we blocked the IL nerve on one side and the IH nerve on the other side (and vice versa during a second session) under direct ultrasound visualization, injecting two times the ED_{95} volume needed to block a peripheral nerve, as determined in a former study.[9]

Methods

After approval of the study by the ethics committee of the canton of Berne (http://www.kek-bern.ch, application no.: 258/07), we recruited 17 healthy volunteers by means of advertisements. Exclusion criteria were age <18 yr, previous surgery in the inguinal region, allergy to local anaesthetics, symptomatic systemic disorders (coronary artery disease, diabetes mellitus, pulmonary disease, renal failure, neurological diseases), history of abnormal bleeding, pathological skin state in the region of interest, missing informed consent, and possible pregnancy (a pregnancy test was carried out in female volunteers). Volunteers showing alterations of sensibility in the region of interest evaluated by pinprick before the first block were excluded from the study.

Ultrasound scanning and measurements before the block

After obtaining written informed consent and performing sensory testing by pinprick in the inguinal region (both sided) by an independent study physician, a bilateral ultrasound assessment using a Sequoia 512® Ultrasound System with a 14 MHz linear ultrasound transducer (15L8w, Acuson Corporation, Mountain View, CA, USA) was performed to identify the nerves. The cross-sectional area of the nerves was measured (as shown in Fig. 1) by the physician performing the blocks later (U.E.), 5 cm cranio-lateral to the anterior superior iliac spine, as defined in our former study.[8]

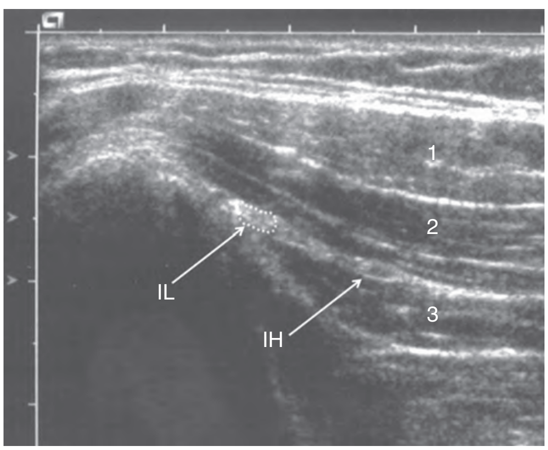

Fig 1 Ultrasound image of the IL and IH nerves between the internal oblique and transverse abdominal muscles, 5 cm cranial and slightly lateral to the anterior superior iliac spine. The IL nerve is encircled by dots to define the circumferential border of the nerve and to allow the ultrasound machine to calculate the cross-sectional area of the nerve. 1, external oblique muscle; 2, internal oblique muscle; 3, transverse abdominal muscle.

Block procedure

The protocol involved two sessions. In a first session, one nerve on one side (e.g. the IL nerve) and the other nerve on the other side (in this case, the IH nerve) were blocked. The nerves to be blocked were determined in a randomized fashion by drawing lots by the physician performing the injection. We prepared two envelopes each with two cards in it. On the cards in the first envelope, left or right was written to choose the side; the cards in the second envelope were marked with IL or IH to choose the nerve to be blocked at the side determined before. For instance, if left and IL were drawn, the IL nerve was blocked on the left side and the IH nerve on the right side during the first session. The volunteer and the physician performing the examination after the block were blinded concerning the blocked nerves. On the occasion of a second session (at the earliest 1 week after the first session), the remaining nerves (not blocked the first time) were blocked in the same way.

Under sterile conditions, 1% mepivacaine was injected around the nerve under ultrasound guidance, using a dose of 0.2 ml mm^{-2} cross-sectional area of the targeted nerve. Based on the dose finding study to evaluate the ED_{95} dose of 1% mepivacaine for an ultrasound-guided peripheral nerve block,[9] we decided to inject two times this ED_{95} dose (0.11 ml mm^{-2}) to have enough local anaesthetic to block the nerve.

A lateral to medial needle approach was chosen for the IL nerve, with the LA being applied laterally to the nerve. For the IH nerve, a medial to lateral needle approach was adopted, and the injection was performed medial to the nerve (Fig. 1). This was done to minimize the risk of spread of the LA to the second nerve. A 23 G/30 mm needle was used (BD Microlance™ 3, Becton Dickinson SA, Fraga, Spain). During injection, the site of spread was carefully watched under ultrasound. Any LA spreading from the nerve to be blocked in the direction of the second nerve (not targeted during the injection) was noted (C.L.).

Evaluation of the block

After 20 min, a second study physician (M.S.) not present during the blocks and blinded concerning the blocked nerves, assessed the anaesthetized skin area by pinprick testing. The test was performed using a 24 G needle, twice with an interval of about 1 s between single stimulations. The corresponding borders of the anaesthetized skin areas were marked on the volunteer's skin with a marker-pen. The anterior superior iliac spine at both sides, the umbilicus and the symphysis, were marked as well and served as the reference points. A measuring rule was put next to the anaesthetized areas for calibration purposes for the calculation of the areas. By means of digital photography, the areas were secured for the purpose of calculation and comparison.

Data analyses

The digital images were processed with a specific software tool developed by us (P.M.S.) using Matlab R2007b (The Mathworks Inc., Natick, MA, USA). Using a graphical user interface, the anaesthetized areas were manually transformed into parameterized polygons and the reference points were selected within the same coordinate system of the picture plane (Fig. 2). The parameterized picture data were then analysed for geometrical parameters. For further analysis of the anaesthetized areas, the parameterized picture data were then transformed into a standardized and unified coordinate system, defined as follows: umbilicus=(0,1), anterior superior iliac spine left=(1,0), symphysis=(0,−1), and anterior superior iliac spine right (−1,0) (Fig. 3). Assuming a certain inaccuracy of our mapping technique (pinprick testing, volunteer's compliance, diameter of the marking pen), we chose a coordinate system's resolution of 24×24 points, which corresponds to a metric resolution of ~0.5–1 cm. To simplify the calculation and comparison of the skin areas, we drew a midline and allocated the anaesthetized skin areas to the corresponding side. The analysis of the anaesthetized skin areas and the individual overlap of the respective areas were performed by using these transformed data and Matlab R2007b.

The overlap of the transformed anaesthetized areas of the different nerves (IL and IH) was assessed in each individual for each side and expressed in the percentage of the smaller anaesthetized area. The acceptance criterion for selective blocks was defined as <25% of the smaller nerve area (e.g. Fig. 3).

In a subgroup analysis, we excluded blocks in which the local anaesthetic could be observed spreading to the second nerve which should not be blocked (e.g. the IH nerve if the IL nerve was target of the block and vice versa).

Exclusion of data

Possible blocks showing the following circumstances and/or results had to be excluded: no sonographically visible neural structure at the injection site, no occurring anaesthesia during the observed time period, or an atypical neuroanatomic finding, that is, a common trunk consisting of both nerves.

Statistics

Only descriptive statistics are used. Data are presented as mean (SD) if not otherwise stated.

Results

From the initially recruited 17 volunteers (nine males, eight females), one male volunteer had to be excluded from the study because of very bad sonoanatomic conditions (Volunteer 17). In this volunteer, it was not even possible to identify the three muscle layers of the abdominal wall clearly by ultrasound. Therefore, in the remaining 16 volunteers, there was in total a potential of 64 nerve blocks. For the analysis, we had to exclude one side in three volunteers (six nerves)

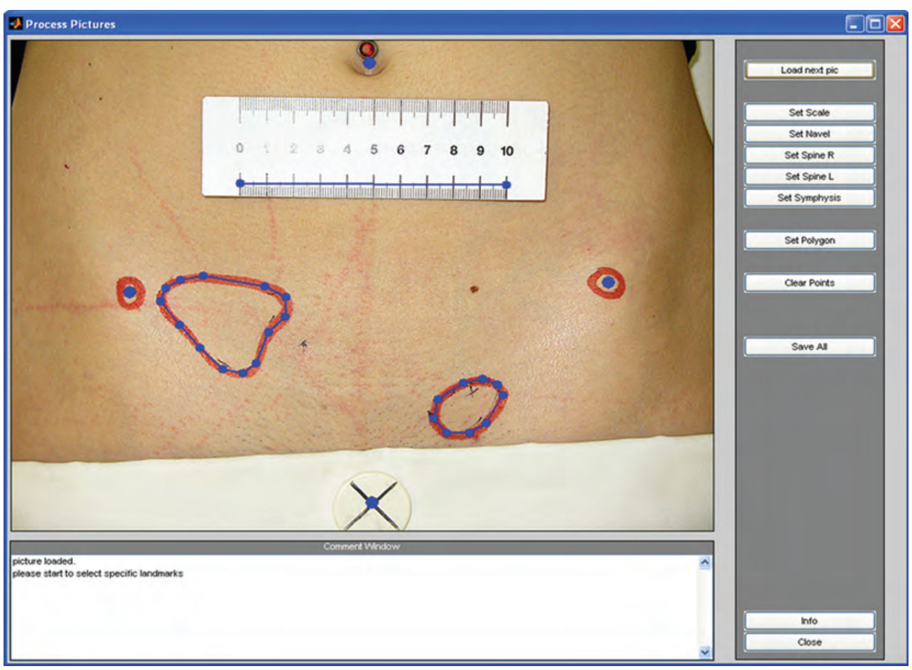

Fig 2 Tool to define the anaesthetized areas and the specific reference points (landmarks). The selection process was done manually by either clicking on the specific landmarks or by drawing a polygon along the boundaries of the anaesthetized areas. The ruler shown served for calibration of the actual image scale. Marks of the pinprick testing can be seen very faintly on the volunteer's skin.

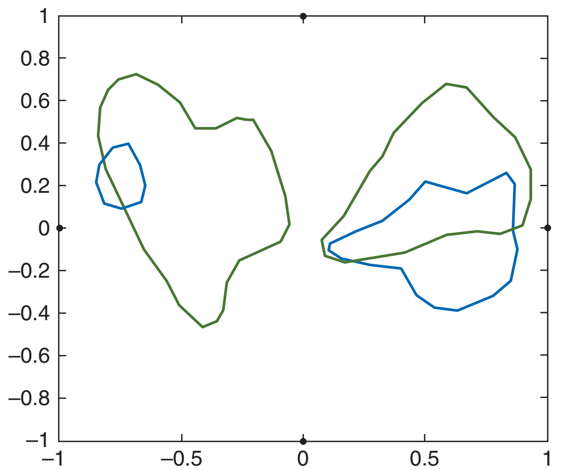

Fig 3 Anaesthetized areas in Volunteer 9. Areas with green and blue coloured borders represent the blockade of the IH (green) and IL (blue) nerve, respectively. The overlap is 52% on the left side and 73% on the right side, respectively.

Table 1 Patient characteristic data of volunteers

	Age (yr)	Weight (kg)	Height (cm)	BMI (kg m^{-2})
Mean	27.6	69.6	174.9	22.6
SD	7.0	11.2	7.1	2.5
Min.	18.0	45.0	160.0	17.6
Max.	45.0	87.0	186.0	27.5

because we found as an anatomical variation a common trunk and not two nerves. In two other volunteers, we could not identify any nerve on one side by ultrasound and had to exclude another four potential blocks. After two blocks, there was no anaesthetized skin area present 20 min after the injection. Because the calculation of an overlap with the corresponding nerve on the same side was not possible, we had to exclude another four nerves from the analysis. Therefore, we could finally analyse 50 nerve blocks.

Patient characteristic data of the volunteers are shown in Table 1. Data of the dimensions of the nerves, their cross-sectional areas, the distances between the two nerves measured by ultrasound, and the volume of 1% mepivacaine injected are shown in Table 2. The mean distance between the two nerves was 12.6 (3.3) mm. The mean injected volume to block the IL and IH nerves was 0.8 (0.3) and 0.9 (0.3) ml, respectively. The respective measured cross-sectional areas were 3.6 (1.1) mm^2 for the IL nerve and 4.3 (1.6) mm^2 for the IH nerve.

We observed direct local anaesthetic spread from one nerve to the other in six out of the 50 blocks analysed (12%). These blocks have been excluded in the subgroup analysis.

Figure 3 shows a typical example of the anaesthetized skin areas from the processed image data (Volunteer 9) and the individual overlaps for both sides. Table 3 shows the percentage of overlap of the blocked skin areas of the IL and IH nerves both sided for all analysed volunteers. On the right side, we had a mean overlap of the blocked areas of 59.9 (28.4) and on the left side of 60.9 (30.7)%. These overlaps did not change at all by excluding the six blocks in which we could directly visualize the spread of local anaesthetic from one nerve to the other (subgroup analysis). The overlap of the anaesthetized skin areas of the two nerves was therefore clearly higher than the predefined maximal accepted overlap of 25% for a selective block of the two nerves. We were defining the percentage of overlap of the blocked skin areas in relation to the smaller area to have a higher sensitivity for a non-selective block. Calculating the percentage of overlap in relation to the larger skin area would lower the percentage of overlap but still not go below the claimed maximal overlap of 25% for a selective block.

Discussion

We were not able to block the IL and the IH nerves separately even by injecting <1 ml of local anaesthetic for each nerve. With a mean overlap area of more than 60%, we did not reach the targeted maximal overlap of 25%.

Even with this low amount of local anaesthetic injected (mean amount of mepivacaine: 0.8 for the IL and 0.9 ml for the IH nerve, respectively), the local anaesthetic seemed to reach both nerves. In six of 50 cases (12%), we could observe local anaesthetic spreading from the targeted nerve to the second nerve. Excluding these cases from the analysis (subgroup analyses) did not change the percentage of overlapping skin areas as shown in Table 3. This may indicate that there was an invisible spread of the local anaesthetic from one nerve to the other in the majority of cases even by using these very small volumes of local anaesthetic solution. Usually, several millilitres are used to block both nerves. In a recently published work, the authors were using 10 ml of local anaesthetic solution to block both nerves together.[10] The reason for an unselective block seems to be the anatomical proximity of the two nerves in the same muscle layer, between the transverse abdominal and the oblique internal abdominal muscles. We found a mean distance between the IL and IH nerves of 12.6 mm which is comparable with the 10.4 mm measured in our anatomical dissection study.[8] We found no anaesthesia in two nerve blocks (IH nerve right in Volunteer 7 and IH nerve left in Volunteer 11). In a former study, we determined the ED_{95} volume per cross-sectional area of the ulnar nerve measured by ultrasound in volunteers. With 0.11 ml mm^{-2}, the nerve was blocked in 95% of cases in this study.[9] By injecting 0.2 ml mm^{-2} cross-sectional area of the nerves in this study, we wanted to inject enough volume to have a block in 100% of cases, while possibly preventing a block of the neighboured nerve. The two observed block failures indicate that

Table 2 Characteristics of the nerves measured by ultrasound and the mean volume injected. The injected volume was calculated according to the cross-sectional area of the respective nerve measured by ultrasound (0.2 ml per mm^2 of cross-sectional area of the nerve). Area, cross-sectional area of the nerve; LA, local anaesthetic; Distance, distance between the IL and the IH nerve

	Diameter (mm)		Depth (mm)	Area (mm^2)	Amount LA (ml)	Distance (mm)
	Horizontal	Vertical				
Ilioinguinal nerve						
Mean	2.7	1.6	15.1	3.6	0.8	
SD	0.7	0.3	2.7	1.1	0.3	
Min.	1.0	0.9	11.0	1.8	0.4	
Max.	4.3	2.5	22.0	7.5	1.7	
Iliohypogastric nerve						
Mean	3.4	1.3	19.6	4.3	0.9	12.6
SD	0.8	0.3	3.3	1.6	0.3	3.3
Min.	2.2	1.0	14.0	2.3	0.5	7.0
Max.	4.6	1.9	28.0	8.0	1.8	20.0

Table 3 All analysed nerve blocks, the reasons for exclusion, and the overlap of the anaesthetized skin areas in percentage of the smaller area in all analysed volunteers (total) and all volunteers without visible spread of local anaesthetic from one nerve to the other (subgroup). The numbers indicate the count of analysed nerve blocks in the respective volunteer and side. IH, iliohypogastric nerve

Volunteer	Overlap skin area total				Overlap skin area subgroup				Comments
	Areas left	Areas right	Overlap left (%)	Overlap right (%)	Areas left	Areas right	Overlap left (%)	Overlap right (%)	
1	2	2	78.1	18.6	2	2	78.1	18.6	
2	2	2	44.6	67.8	1	2		67.8	
3	2	2	31.5	59.6	2	2	31.5	59.6	
4	2	2	91.4	78.0	2	2	91.4	78.0	
5	2	2	39.0	62.4	2	2	39.0	62.4	
6	2	2	82.5	95.5	2	2	82.5		
7		1				1			Common trunk left, no anaesthesia IH right
8	2	2	88.2	61.5	2	2	88.2	61.5	
9	2	2	51.8	73.3	2	2	51.8	73.3	
10		2		48.9		1			No nerves visible left
11	1	2		0.4		2		0.4	No anaesthesia IH left
12	2	2	96.7	87.8	2	1	96.7		
13	2	2	5.2	90.7	1	2		90.7	
14									Common trunk right, no nerves visible left
15		2		22.1		1			Common trunk left
16		2		71.4		2		71.4	No nerves visible left
Mean			60.3				63.5		
SD			28.7				26.5		
Min.			0.4				0.4		
Max.			96.7				90.7		

two times the ED_{95} volume may be too low to produce a profound block of the targeted nerves in 100% of cases. Alternatively, we may have targeted a structure other than the nerve. We cannot exclude that the inguinal nerves need more volume per square millimetre of cross-sectional area than the ulnar nerve to be blocked. In a dose reduction study dealing with the sciatic nerve, the authors found a volume of 1.5% mepivacaine of 0.10 ml mm^{-2} to block the nerve in 99% of cases,[11] which is similar to the ED_{95} volume we found for 1% mepivacaine and the ulnar nerve. Another possible explanation for the two failed blocks could be the spread of local anaesthetic to the second nerve, which could be directly observed in one of the two cases, with consequent reduction in the amount of local anaesthetic for the primarily targeted nerve. Because we did not find an anaesthetized skin area in the two cases mentioned, reducing the volume of local anaesthetic further than we did in this study does not seem to be reasonable.

We found an overlap of more than 60% of the skin areas of the IL and the IH nerves after each single block. The most probable explanation for this finding is a partial block of both nerves in most cases, strengthened by the observation of visualizing a spread of local anaesthetic from one nerve to the other in 12% of cases. From this point of view, the injected volume of 0.2 ml mm^{-2} seems to be too high.

We observed an existing common trunk instead of the two separate nerves in three cases (9.4%). This is in accordance with the published data in basic anatomical work, where the authors found a common trunk in 12.6% of 348 investigated specimens.[12]

Some limitations of the study have to be discussed. The sensory innervation of the groin's skin area is complex. Besides the IL and the IH nerves, the genitofemoral nerve is involved. The variability of the course of these nerves is quite high,[12] [13] the distribution of the sensory innervated skin areas is very high, and there is an extensive overlap in terms of skin innervations,[14] as in other anatomical regions. Communicating branches between the three nerves are present[14] and may transmit excitatory impulses to the central nervous system even if the targeted nerves are totally blocked. We cannot exclude that the overlapping skin innervations of the targeted nerves and therefore the lack of area propria of skin innervations for each single nerve explain our findings. If this is true, the overlap that we observed would not be the result of the lack of selective block, but rather of lack of separate and selective innervations areas of the two nerves. One can argue that the chosen maximal overlap of 25% for the definition of a selective block in this study is too low, especially if we take the known overlapping innervations of skin area of the involved nerves as mentioned above into account. As far as we know, our study is the first one dealing with an ultrasound-guided selective block of nerves with a close anatomical relationship. Therefore, we were not able to find any literature to help us define a maximal overlapping skin area for a selective block. On the other hand, even by choosing a maximal overlap of 50% as definition would not have changed our result, because we found an overlap of more than 60%. For further studies dealing with selective nerve blocks, the definition of the maximal overlapping area for a selective block will still remain a difficult topic. In the end, we cannot clearly distinguish whether the measured overlapping skin area after the blocks in our study is the result of the overlapping anatomical skin areas of the two nerves or of the spread of local anaesthetic from one nerve to the other. Both explanations do not influence the conclusion that a selective block of the IL and the IH nerves is not possible, as far as our test modalities are based on clinical testing of the involved skin areas.

In a recently published placebo-controlled study, Bischoff and colleagues[10] found no benefit by performing diagnostic ultrasound-guided inguinal and IH nerve blocks in 12 patients suffering from chronic pain after inguinal hernia repair. They stated that the complex sensory innervations and possible important pathophysiological role of the genitofemoral nerve in chronic pain in this groin region were possible explanations for the negative finding.[10] Our study also underlines that the interpretation of diagnostic blocks of inguinal nerves has to be done with care and further studies are needed to understand postherniorrhaphy pain.

Conclusions

A selective block of the IL nerve and the IH nerve between the internal oblique and transverse abdominal muscle seems to be unfeasible, even if volumes below 1 ml of 1% mepivacaine are used for each single nerve. The nerves are lying in the same layer of the abdominal wall and the most likely explanation is the spread of local anaesthetic from one nerve to the other.

Declaration of interest

U.E. has received research grant support and speaker honoraria from SonoSite Inc., Seattle, USA, in the past 5 yr.

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