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Review Article

Suitability of Alternatives to Rectal Temperature Measurements in Pet Rodents, Rabbits and Ferrets: A Literature Review

Key words

rectal temperature,
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Jelle Stans

Institute for Globally Distributed Open Research and Education, Beringen, Belgium

***Corresponding author:** jelle.stans@igdore.org

Abstract: Body temperature is a vital parameter to assess the health of exotic animals. Rectal thermometry is a common way to measure body temperature in rodents, rabbits and ferrets and often considered the gold standard. However, taking a rectal temperature often involves restraint and can lead to stress in these animals. To avoid the stress of rectal temperature measurements, alternative (often less invasive) techniques have been utilized in several species. These methods include tympanic thermometry, axillary thermometry and infrared thermography. It is however important to establish whether these strategies yield comparable readings to the gold standard. Therefore, a literature review was performed using the MedLine and Google Scholar databases. Base terms referring to rectal temperature and thermometry were combined with species-specific search terms. Relatively few studies were identified about alternatives to rectal temperature measurements in rodents, rabbits and ferrets. In general, it can be noted that only transponder measurements have repeatedly been described to be a valid alternative to rectal temperature measurement. Further research should be conducted.

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Introduction

Body temperature is a vital parameter to assess the health of exotic animals (1). An elevated body temperature can signal an infection or systemic inflammation (2) while hypothermia may, for example, arise as a complication as a complication of general anaesthesia and surgery (3). In rodents and rabbits, body temperature was shown to be of prognostic value in a clinical setting (4, 5).

Rectal thermometry is a common way to measure body temperature in rodents (6), rabbits (7) and ferrets (8) and often considered the gold standard. However, taking a rectal temperature often involves restraint and can lead to stress in these animals (9, 10). This can, amongst others, impact the readings (11).

To avoid the stress of rectal temperature measurements, alternative (often less invasive) techniques have been utilized in several species. These methods include tympanic thermometry (12), axillary thermometry (13) and infrared thermography (14). It is however important to establish whether these strategies yield comparable readings to the gold standard. In cats and dogs, such studies have been conducted suggesting that alternative methods are not always a good replacement for rectal thermometry (14, 15). In rodents, rabbits and ferrets, the body of literature comparing temperature measurement seems to be limited while this is a particularly important topic because of the stress-inducing consequences of rectal thermometry.

Therefore, the aim of the current review article is to summarize the non-invasive temperate measure methods investigated in pet rodents, rabbits and ferrets and assess whether they are a suitable alternative to rectal temperature measurement. Additionally, suggestions for further research are formulated.

Search strategy and inclusion

Between the 3rd and 5th of September 2022, the MedLine database was searched through Pubmed. The base term "("rect*") AND (("temp*") OR ("therm*"))" was combined with species-specific terms: "AND (("guinea pig*") OR ("cavy") OR ("cavies"))", "AND (("mouse*") OR ("mice"))", "AND (("rat") OR ("rats"))", "AND ("hamster*")", "AND ("gerbil*")", "AND ("degu*")", "AND ("chinchilla*")", "AND ("rabbit*")" and "AND ("ferret*")". Google Scholar was searched during the same period with the base term "rectal temperature" combined with the following species-specific terms: "guinea pig*", "mice", "rat*", "hamster*", "gerbil*", "degu*", "chinchilla*", "rabbit*" and "ferret*".

The titles of the publications in the search results were screened for papers that could be eligible for inclusion. The abstracts of potentially eligible publications were read and included if (1) they described a comparison between rectal temperature measurement and at least one non-invasive method, (2) described agreement between rectal measurement and a non-invasive method and (3) the study was conducted in at least one eligible species (rodent, ferret or rabbit).

Characteristics of included studies

The searches yielded eligible studies for guinea pigs (3 studies, 16-18), mice (5 studies; 16, 19-22), rats (4 studies; 9, 19, 23-24), chinchillas (1 study, 25), rabbits (3 studies; 7, 16, 26) and ferrets (3 studies; 8, 27, 28). No eligible studies were identified for hamsters, gerbils and degus. The included studies and important characteristics are shown in table 1. All publications described prospective studies of multiple animals with sample sizes ranging from 6 to 48. Studies were conducted in both healthy animals and patients. In selected studies, there was a focus on laboratory animals. Publication dates ranged from 1997 and 2021, but it is clear that a significant number was published over 15 years ago.

Suitability of alternative methods per species

In Guinea pigs, two studies (16,17) investigated the use of transponders to measure body temperature, with mixed results. Both studies were conducted in an experimental setting using animals raised as laboratory animals. One study mentioned it to be a valid alternative to rectal temperature (17) while the other mentioned it was not (16). Other methods compared to rectal temperatures were tympanic, laser, axillary and inguinal thermometry (4, 17, 18). None of these methods were mentioned to be a valid alternative for rectal temperature measurement. The authors of the second study (17) mentioned that the transponder system they used made sounds that may be disturbing to the guinea pigs. Additionally, they stated that due to the hand-held nature of non-contact thermometers, it is difficult to obtain measurements from a comparable distance.

In mice, microchip transponders were also investigated, both subcutaneously and intraperitoneally (16, 19). One of these studies reported subcutaneously and intraperitoneal transponders to be a valid alternative to rectal temperature measurement (19). One study also mentioned infrared thermometry of the ear and back skin to be a valid alternative (20). They also stated that this technique allows skin temperature to be measured easily at these sites. Other strategies were not deemed a suitable alternative in all cases (20, 21, 22). All of these studies were performed in laboratory animals.

In rats, microchip transponders (intraperitoneally and subcutaneously) and (temperature-sensitive) telemetry were deemed to be usable alternatives to rectal thermometry (9,19, 23, 24). However, as stated above, it is important to assess whether the specific detection method does not disturb the animals. Additionally, the telemetry was only investigated in a research setting (9, 23). This means it should be assessed whether these results can be translated to the clinic. Finally, all of these studies were performed in laboratory rats.

Human and veterinary thermometers were investigated as an alternative to rectal temperature measurement in chinchillas (25). Unfortunately, both methods were deemed unsatisfactory. In this case, the studies were also conducted in an experimental setting. The animals were sourced from breeding facilities. Thermography was assessed in the eye, inner ear, external ear and nose of rabbits (26). The publication mentioned that this was an effective tool to measure the temperature of several regions. However, this is not the same as being a reliable alternative for body temperature measurement in a clinical setting.

Implantable microchip transponders were mentioned as a suitable alternative (7). Noncontact infrared thermometer (ear and thigh) and tympanic thermometer (human and veterinary) were not a replacement for rectal temperature measurement (7). All of these studies were performed in a research setting with laboratory animals.

In ferrets, microchip transponder thermometry was mentioned as an alternative to rectal temperature measurement (8). Paediatric and veterinary auricular, axillary, dorsal skin, inguinal, noncontact infrared and tympanic thermometry were not deemed to be alternatives (27, 28). One study (27) was conducted in animals presented within a clinical setting. The other studies were conducted in an experimental setting in laboratory animals.

Discussion

Relatively few studies have been published about alternatives to rectal temperature measurements in rodents, rabbits and ferrets. The internal and external validity of the published studies also leaves room for improvement. In general, it can be noted that only transponder measurements have

Table 1: Study design of includes studies

Reference	Title	Study design	Sample size	Database	
	Guinea pigs				
Hartinger et al., 2003	Suitability of temperature-sensitive transponders to measure body temperature during animal experiments required for regulatory tests	Prospective	10	PubMed	
Devalle, 2005	Comparison of tympanic, transponder, and noncontact infrared laser thermometry with rectal thermometry with rectal thermometry in strain 13 Guinea pigs (Cavia porcellus)	Prospective	28	PubMed	Google Scholar
Levy et al., 2020	Comparison of axillary and inguinal body temperature to rectal temperature in healthy guinea pigs (Cavia porcellus)	Prospective	40		Google Scholar
	Mice				
Kort et al., 1997	A microchip implant system as a method to determine body temperature of terminally ill rats and mice	Prospective	10	PubMed	Google Scholar
Hartinger et al., 2003	Suitability of temperature-sensitive transponders to measure body temperature during animal experiments required for regulatory tests	Prospective	12	PubMed	
Saegusa and Tabata, 2003	Usefulness of infrared thermometry in determining body temperature in mice	Prospective	6	PubMed	
Newsom et al., 2004	Comparison of body surface temperature measurement and conventional methods for measuring temperature in the mouse	Prospective	12	PubMed	Google Scholar
Fiebig et al., 2018	Evaluation of Infrared thermography for temperature measurement for temperature measurement in adult male NMRI nude mice	Prospective	10	PubMed	
	Rats				
Dilsaver et al., 1992	Measurement of temperature in the rat by rectal probe and telemetry yields compatible results	Prospective	12	PubMed	Google Scholar
Kort et al., 1997	A microchip implant system as a method to determine body temperature of terminally ill rats and mice	Prospective	30	PubMed	Google Scholar
Eshraghi et al., 2005	Cochlear temperature correlates with both temporalis muscle and rectal temperatures. Application for testing the otoprotective effect of hypothermia	Prospective	6	PubMed	Google Scholar
Dangarembizi et al., 2017	Measurement of body temperature in normothermic and febrile rats: Limitations of using rectal thermometry	Prospective	31	PubMed	Google Scholar
	Hamsters				
	Gerbils				
	Degus				
	Chinchillas				
Ozawa et al., 2017	Comparison of rectal and tympanic thermometry in chinchillas (Chinchilla lanigera)	Prospective	47	PubMed	Google Scholar
	Rabbits				
Hartinger et al., 2003	Suitability of temperature-sensitive transponders to measure body temperature during animal experiments required for regulatory tests	Prospective	10	PubMed	
Chen and White, 2006	Comparison of rectal, microchip transponder, and infrared thermometry techniques for obtaining body temperature in the laboratory rabbit (Oryctolagus cuniculus)	Prospective	46	PubMed	Google Scholar
Jaén-Téllez et al., 2021	Relationship between rectal temperature measured with a conventional thermometer and the temperature of several body regions measured by infrared thermography in fattening rabbits. Influence of different environmental factors	Prospective	48		Google Scholar
	Ferrets				
Maxwell et al., 2016	Comparison of digital rectal and microchip transponder thermometry in ferrets (Mustela putorius furo)	Prospective	16	PubMed	Google Scholar
Aguilar et al., 2018	Comparison of body temperature acquired via auricular and rectal methods in ferrets	Prospective	27		Google Scholar
Keeney et al., 2020	Comparison of body temperature using digital, infrared, and tympanic thermometry in healthy ferrets (Mustela putorius furo)	Prospective	20		Google Scholar

repeatedly been described to be a valid alternative to rectal temperature measurement.

It is clear that there is a difference in number of studies per species. One potential reason for the higher number of studies in mice and rats is that they are often used as laboratory animals. Temperature measurements are often performed in animal experiments (6) and need to be reliable and not be impacted by stress-induced responses. This may stimulate research into this area, which can be translated into clinical practice. Further research is needed to address the lack of studies in hamsters, gerbils and degus.

Table 2: Data extracted from included studies

Reference	Alternative temperature measurement method	Agreement metric with rectal measurement	Valid alternative for rectal measurement according to publication?
		Guinea pigs	
Hartinger et al., 2003	Implanted temperature-sensitive transponders	Only graphically	No
Devalle, 2005	Tympanic thermometer	0.3956 intraclass correlation coefficient	No
Devalle, 2005	Laser	0.1229 intraclass correlation coefficient	No
Devalle, 2005	Transponder	0.5880 intraclass correlation coefficient	Yes
Levy et al., 2020	Axillary	difference of mean -0.39 (95% CI -0.54 - -0.23)	No
Levy et al., 2021	Inguinal	difference of mean was -0.73 (95% CI -0.94 - -0.52)	No
		Mice	
Kort et al., 1997	Microship transponder (subcutaneous)	differences within ± 0.5°C	Yes
Kort et al., 1997	Microship transponder (intraperitoneally)	differences within ± 0.5°C	Yes
Hartinger et al., 2003	Implanted temperature-sensitive transponders	Only graphically	No
Saegusa and Tabata, 2003	Infrared thermometry (ear)	correlation r = 0.95	Yes
Saegusa and Tabata, 2003	Infrared thermometry (back skin)	correlation r = 0.96	Yes
Saegusa and Tabata, 2003	Infrared thermometry (tail skin)	correlation r = 0.59	No
Saegusa and Tabata, 2003	Infrared thermometry (sole skin)	correlation r = 0.59	No
Newsom et al., 2004	Surface temperature measurements	correlation r = 0.9773	No
Newsom et al., 2004	Telemetry	correlation r = 0.9699	No
Fiebig et al., 2018	Infrared Thermography/Camera	mean difference of 0.56 °C	Yes* (in nude mice)
		Rats	
Dangarembizi et al., 2017	Temperature-sensitive radiotelemeters (intraperitoneally)	rectal 0.5°C lower or 0.7°C greater than radiotelemeter	Yes* (but investigated for research setting)
Eshraghi et al., 2005	Cochlear temperature	Correlation r = 0.959	No
Kort et al., 1997	Microship transponder (subcutaneous)	differences within ± 0.5°C	Yes
Kort et al., 1997	Microship transponder (intraperitoneally)	differences within ± 0.5°C	Yes
Dilsaver et al., 1992	Telemetry	after salicylate r = +0.83, after oxotremorine r = +0.93	Yes* (but investigated for research setting)
		Hamsters	
		Gerbils	
		Degus	
		Chinchillas	
Ozawa et al., 2017	Human tympanic thermometer	margin of error (combined human/veterinary) 1.7°C	No
Ozawa et al., 2017	Veterinary tympanic thermometer	margin of error (combined human/veterinary) 1.7°C	No
		Rabbits	
Hartinger et al., 2003	Implanted temperature-sensitive transponders	Only graphically	No
Chen and White, 2006	Implantable microchip transponder	95% agreement limit: ±1.48	Yes
Chen and White, 2006	Noncontact infrared thermometer (ear)	Not calculated due to systematic deviations from avg temp	No
Chen and White, 2006	Noncontact infrared thermometer (thigh)	Not calculated due to systematic deviations from avg temp	No
Chen and White, 2006	Human tympanic thermometer	Not calculated due to systematic deviations from avg temp	No
Chen and White, 2006	Animal tympanic thermometer	Not calculated due to systematic deviations from avg temp	No
Jaén-Téllez et al., 2021	Thermography (eye)	Coefficient of determination: 0.15	Unclear
Jaén-Téllez et al., 2021	Thermography (inner ear)	Coefficient of determination: 0.22	"Best"
Jaén-Téllez et al., 2021	Thermography (external ear)	Coefficient of determination: 0.24	"Inefficient"
Jaén-Téllez et al., 2021	Thermography (nose)	Coefficient of determination: 0.20	Unclear
		Ferrets	
Maxwell et al., 2016	Microchip transponder thermometry	95% Agreement limits (°F): −1.82 to +1.96 (comp. to calibrated rectal) −2.19 to +0.84 (comp. to common rectal)	Yes
Aguilar et al., 2018	Pediatric auricular thermometers	correlation thermometer 1: 0.4726 correlation thermometer 2: 0.5388	No
Aguilar et al., 2018	Veterinary auricular thermometers	correlation 0.6311	No
Keeney et al., 2020	Axillary	95% CI of Mean Difference -1.32, -0.67	No
Keeney et al., 2020	Dorsal Skin	95% CI of Mean Difference -0.14, 0.24	No* (possibly after further studies)
Keeney et al., 2020	Inguinal	95% CI of Mean Difference -1.15, -0.63	No
Keeney et al., 2020	Noncontact Infrared	95% CI of Mean Difference -8.37, -6.43	No
Keeney et al., 2020	Tympanic	95% CI of Mean Difference -0.78, -0.38	No

A further limitation is that most of the studies were conducted in an experimental setting and may therefore not fully resemble the clinical setting. Additionally, only one study was performed with animal patients while the rest were conducted with laboratory animals. These animals may have different relevant characteristics than patients, including different stress sensitivity.

For now, it seems that rectal temperature measurement should remain the golden standard until further research has been performed.

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Ustreznost alternativnih tehnik rektalnemu merjenju temperature pri hišnih glodavcih, kuncih in belih dihurjih - pregled literature

J. Stans

Izvleček: Telesna temperatura je pomemben parameter za oceno zdravja eksotičnih živali. Rektalno merjenje temperature je običajen način merjenja telesne temperature pri glodavcih, kuncih in belih dihurjih in pogosto velja za zlati standard. Vendar je merjenje rektalne temperature pri teh živalih pogosto povezano z omejevanjem gibanja in povzročanjem stresa. Da bi se izognili stresu pri merjenju rektalne temperature, so bile pri več vrstah živali uporabljene alternativne (pogosto manj invazivne) tehnike. Te metode vključujejo infrardečo termografijo ter merjenje temperature timpanično in aksilarno. Vendar pa je pomembno ugotoviti, ali te strategije dajejo primerljive rezultate z zlatim standardom. Zato smo opravili pregled literature z uporabo podatkovnih zbirk MedLine in Google Scholar. Osnovni izrazi, ki se nanašajo na rektalno temperaturo in merjenje temperature, so bili združeni z iskalnimi izrazi, značilnimi za posamezne vrste. Pri glodavcih, kuncih in belih dihurjih je bilo najdenih razmeroma malo študij o alternativah rektalnim meritvam temperature. Na splošno lahko ugotovimo, da so bile le meritve s transponderjem večkrat opisane kot veljavna alternativa rektalnemu merjenju temperature. Potrebne so nadaljnje raziskave.

Ključne besede: rektalna temperatura; glodavci; kunci; beli dihurji; alternative