Disorders of the Nervous System

Investigation of MicroRNA-134 as a Target against Seizures and SUDEP in a Mouse Model of Dravet Syndrome

Rogério R. Gerbatin,1,2 Joana Augusto,1,4 Gareth Morris,1,2,5 Aoife Campbell,1,2 Jesper Worm,6 Elena Langa,1,2 Cristina R. Reschke,1,2,3,* and David C. Henshall1,2,*

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1Department of Physiology and Medical Physics, RCSI University of Medicine and Health Sciences, Dublin, D02 YN77, Ireland, 2FutureNeuro SFI Research Centre, RCSI University of Medicine and Health Sciences, Dublin, D02 YN77, Ireland, 3School of Pharmacy and Biomedical Sciences, RCSI University of Medicine and Health Sciences, Dublin, D02 YN77, Ireland, 4Department of Physiology, Faculty of Medicine, Trinity College Dublin, Dublin, D02 PN40, Ireland, 5Department of Neuroscience, Physiology and Pharmacology, University College London, London, WC1E 6BT, United Kingdom, and 6Roche Innovation Center Copenhagen, Copenhagen, CH-4070, Denmark

Visual Abstract

Other seizure / epilepsy models
PTZ, PPS, Kainate, Pilocarpine

Dravet Syndrome
F1.Scn1a(+/−)tm1kea mice

Significance Statement

Several preclinical models of epilepsy have implicated microRNA-134 (miR-134) as a therapeutic target for seizure control and anti-epileptogenesis. The present study here explored whether targeting miR-134 has effects on seizures and mortality in a mouse model of Dravet syndrome (DS). The results indicate that suppression of miR-134 using an antimiR (Ant-134) did not protect against hyperthermia-induced seizures, spontaneous seizures or SUDEP in F1.Scn1a(+/−)tm1kea mice. The findings suggest that miR-134 is not a therapeutic target in DS.
Dravet syndrome (DS) is a catastrophic form of pediatric epilepsy mainly caused by noninherited mutations in the SCN1A gene. DS patients suffer severe and life-threatening focal and generalized seizures which are often refractory to available anti-seizure medication. Antisense oligonucleotides (ASOs) based approaches may offer treatment opportunities in DS. MicroRNAs are short noncoding RNAs that play a key role in brain structure and function by post-transcriptionally regulating gene expression, including ion channels. Inhibiting miRNA-134 (miR-134) using an antimiR ASO (Ant-134) has been shown to reduce evoked seizures in juvenile and adult mice and reduce epilepsy development in models of focal epilepsy. The present study investigated the levels of miR-134 and whether Ant-134 could protect against hyperthermia-induced seizures, spontaneous seizures and mortality (SUDEP) in F1.Scn1a(+/−)tm1kea mice. At P17, animals were intracerebroventricular injected with 0.1–1 nmol of Ant-134 and subject to a hyperthermia challenge at postnatal day (P)18. A second cohort of P21 F1.Scn1a(+/−)tm1kea mice received Ant-134 and were followed by video and EEG monitoring until P28 to track the incidence of spontaneous seizures and SUDEP. Hippocampal and cortical levels of miR-134 were similar between wild-type (WT) and F1.Scn1a(+/−)tm1kea mice. Moreover, Ant-134 had no effect on hyperthermia-induced seizures, spontaneous seizures and SUDEP incidence were unchanged in Ant-134-treated DS mice. These findings suggest that targeting miR-134 does not have therapeutic applications in DS.

**Key words:** Dravet syndrome; miR-134; oligonucleotides; seizure; SUDEP

**Introduction**

Epilepsy is a common, chronic brain disease characterized by an enduring predisposition to generate epileptic seizures (Fisher et al., 2014). Most monogenic causes of epilepsy arise from inherited or de novo mutations in genes that encode protein components of ion channels or neurotransmitter systems. This includes Dravet syndrome (DS), an intractable form of childhood epilepsy with an incidence of 1:15,700 births (Wu et al., 2015). Most DS patients carry de novo mutations in one allele of the SCN1A gene leading to haploinsufficiency of the type 1 voltage-gated sodium channel α subunit (Nav1.1). Since Nav1.1 is enriched in fast-spiking parvalbumin (PV) interneurons, loss-of-function mutations in SCN1A result in reduced Na⁺ influx leading to reduced firing of inhibitory neurons and brain hyperexcitability (Yu et al., 2006; Jiang et al., 2018).

The earliest DS symptoms in both humans and mouse models are primarily characterized by sensitivity to hyperthermia-induced seizures (Oakley et al., 2009; Gataullina and Dulac, 2017). Severe spontaneous recurrent seizures (SRS) emerge soon after and there is a high incidence of sudden unexpected death in epilepsy (SUDEP) (Shmuely et al., 2016). Seizures in DS patients are largely refractory to current therapies. Although seizure frequency declines with age, individuals with DS often experience long-lasting cognitive and motor impairments (Genton et al., 2011; Shmuely et al., 2016). Therefore, there is an urgent need to find effective treatments for this catastrophic childhood epilepsy.

Precision therapies designed to restore SCN1A expression recently entered clinical trials (NCT04740476, NCT04442295). However, most recently approved therapies for DS remain nonprecision therapies involving broad targets to regulate brain excitability including cannabidiol, stiripentol and fenfluramine. In addition to these small molecules, a recent study using antisense oligonucleotides (ASOs) to knock-down the TAU protein in neurons reduced epilepsy, SUDEP, and autism-like behavior in a mouse model of DS (Shao et al., 2022). These studies highlight that SRS, SUDEP and behavior impairments in DS can be controlled by distinct mechanisms associated with brain excitability but not necessarily linked directly to the genetic mutation. The effectiveness of these therapies at different life-stages of DS remains unclear, however, necessitating the pursuit of additional strategies.

MicroRNAs (miRNAs) are small noncoding RNAs which have emerged as potential treatment targets in epilepsy (Brennan and Henshall, 2020; Chakraborty et al., 2021; Morris et al., 2021). Several miRNAs play crucial roles in brain development by tightly regulating post-transcriptional expression of genes implicated in brain excitability and neuronal network function (Follert et al., 2014). Among these, miRNA-134 (miR-134) is a leading candidate, a brain-enriched neuronal miRNA which has been reported to be upregulated in preclinical rodent models of seizures and epilepsy and in resected brain tissue from children and adults with drug-resistant temporal lobe epilepsy (TLE) (Jimenez-Mateos et al., 2012; Peng et al., 2013; Reschke et al., 2017).

The broad effect in multiple rodent models of seizures and epilepsy using locked nucleic acid oligonucleotide
ASOs called antimiRs (Ant-134) have been linked to derepression of structural and transcriptional proteins including Lim-domain-containing protein kinase1 (Limk1), Doublecortin (Dcx), and cAMP response element binding protein (Creb1), which can directly alter synaptic function and brain excitability (Schratt et al., 2006; J Gao et al., 2010; Gaughwin et al., 2011; Morris et al., 2019). Thus, Ant-134 promotes a potent seizure reduction in adult models of evoked seizures and epilepsy (Jimenez-Mateos et al., 2012; Reschke et al., 2021). Targeting miR-134 also models of evoked seizures and epilepsy (Jimenez-Mateos et al., 2012; Reschke et al., 2021). Targeting miR-134 also reduces kainic acid-induced seizures, at least within a narrow dose-range, in juvenile (P21) mice (Campbell et al., 2021). Interestingly, in a mouse model of Angelman syndrome carrying a loss-of-function mutation in the maternally-inherited copy of the Ube3a gene, Ant-134 treatment also reduced effectively the susceptibility to audiogenically-evoked seizures (Campbell et al., 2022). Whether targeting miR-134 has effects in other models of genetic epilepsy is unknown, although ion channel-specific epilepsies can be treated by miRNA-targeting antimiRs in mice (Gross et al., 2016; Tiwari et al., 2019).

Here, we investigate whether miR-134 suppression would protect against hyperthermia-induced seizures, SRS and SUDEP in F1.Scn1a(+/−)tm1kea mice by directly regulating proteins related to synaptic function and brain excitability commonly associated with the prolonged and sustained effects of Ant-134 on epilepsy. The results show that ant-134 treatment is not effective in suppressing seizures in F1.Scn1a(+/−)tm1kea mice, suggesting that miR-134 is not able to modulate the epileptogenic process in DS and does not represent a therapeutic target for the disease.

Materials and Methods

Mice and ethics statement

Scn1a(+/−)tm1kea mice which have a deletion of the first coding exon were generated by homologous recombination in TL1 ES cells (129S6/SvEvTac) as previously described (Miller et al., 2014). Male Scn1a(+/−)tm1kea mice on the 129S6/SvEvTac background were crossed with inbred female mice C57BL/6JolaHsd resulting in [129XB6]F1.Scn1a(+/−) mice offspring, referred to herein as F1.Scn1a(+/−)tm1kea. Both male and female F1.Scn1a(+/−)tm1kea or wild-type (WT) littermates F1. Scn1a(+/−)tm1kea used in experiments were genotyped before postnatal day (P)7. All animal experiments were performed in accordance with the European Communities Council Directive (86/609/EEC) and approved by the Research Ethics Committee of the Royal College of Surgeons in Ireland (REC 1302bbb) under license from the Department of Health (AE19127/P064), Dublin Ireland. Animals were maintained in a light (8 A.M. to 8 P.M.)/dark cycle (8 P.M. to 8 A.M.) with food and water ad libitum.

Intracerebroventricular injections of antimiRs

At P17, mice were weaned and injected intraperitoneally with buprenorphine (0.3 mg/ml) and placed in an adapted stereotaxic frame under anesthesia (isoflurane/oxygen 5% for induction and 3% for maintenance). Body temperature was maintained by a feedback-controlled heat blanket. After topical application of EMLA cream 5%, a midline scalp incision was performed and a craniotomy was drilled to allow direct ICV injections [coordinates from bregma: anterior–posterior (AP) = +0.3 mm, lateral (L) = +0.9 mm, ventral (V) = −1.35 mm relative to the dura mater; see Extended Data Fig. 1-1 for representative images of intracerebroventricular injections in P21 mice]. Mice were randomly assigned into 5 different groups: (+/+)scr 1 nmol, (+/−)scr 1 nmol, (+/−)Ant-134 0.1 nmol, (+/−)Ant-134 0.5 nmol, and (+/−)Ant-134 1 nmol to receive three different doses of mmu-miR-134-5p miRCURY LNA inhibitor (Ant-134; Exiqon; 0.1, 0.5 or 1 nmol in 2 μl PBS) or a nontargeting scrambled control (scr; Exiqon, 1 nmol in 2 μl PBS) using a 2-μl Hamilton syringe at a rate of 1 μl/min. After surgery, animals were immediately placed in an incubator at 33°C and monitored for 30 min before returning to the home cage.

Ant-134 testing on hyperthermia-induced seizures during the febrile stage of DS

At P18, animals were subjected to a hyperthermia-induced seizure threshold assay as previously described (Gerbatin et al., 2022). First, the mouse was gently hand-restrained in a supine position with tail lifted. Then, a temperature probe (RET-4, physitemp) covered with Vaseline was inserted into the rectum and taped on the tail, to keep it in place throughout the procedure. Then, animals were placed into a Plexiglas box with an infrared heat lamp (HL-1, physitemp) positioned above and the rectal probe attached to a TCAT-2DF thermometer (physitemp). Mice were held at 37.5°C for 5 min to become accustomed to the chamber. Then core body temperature was gradually elevated by 0.5°C every 2 min until a seizure occurred or until reaching 42.5°C. If reaching that temperature, animals were held for 3 min before turning off the heat lamp. After that, mice remained 5 min in the chamber for observation of any late occurring seizures before they were removed, cooled down and considered seizure free. If the mouse had a seizure during the hyperthermia challenge, the heating process was stopped immediately to cool down the mouse to 37°C on a cold metal surface. Seizure severity was classified according to the Racine scale scoring system with few modifications (Racine, 1972; Van Erum et al., 2019). No behavior changes (0), mouth and facial movements (1), head nodding (2), unilateral forelimb clonus (3), bilateral forelimb clonus with rearing (4), rearing and falling (loss of posture; 5), wild running or jumping (6), and tonic hindlimb extension possibly leading to death (7).

Measurement of miR-134 and antimiR knock-down

To evaluate miR-134 and antimiR levels in the febrile stage, animals received an intraperitoneal overdose of pentobarbital 30 min after the hyperthermia challenge to be transcardially perfused with ice-cold PBS to remove the brain and microdissect the cortex and hippocampus for molecular analyses. During the worsening stage of DS, a subgroup of mice intracerebroventricularly injected at P21 with Ant-134 0.1 nmol, were also euthanized 24 h later (at P22) to evaluate...
the silencing of miR-134 in cortex and hippocampus. RNA was extracted from the ipsilateral hippocampus and cortex using 750 μl of TRIZol (Sigma-Aldrich), to homogenize the samples followed by a centrifugation at 12,000 × g for 10 min at 4°C. Phase separation was performed by adding 200 μl of chloroform (Sigma-Aldrich), to each sample and vigorously mixing for 15 s before incubating at room temperature for 5 min. Samples were centrifuged at 15,600 × g for 15 min at 4°C. The upper phase was removed and ethanol was removed. Finally, pellets were left to dry for 1 h.

Samples were centrifuged at 13,300 g at 20°C overnight. Samples were centrifuged at 12,000 g for 1 min and placed in the QuantStudio 12K Flex PCR system. Comparative CT values were measured. miRNA levels were normalized using RNU19 (Applied Biosystems miRNA assay ID 001003) expression and relative fold change in miRNA levels were calculated using the comparative cycle threshold method (2-ΔΔCT).

**Analysis of mRNA expression**

qPCR was performed using the QuantiTech SYBR Green kit (QIAGEN) and the LightCycler 1.5 (Roche Diagnostics). Each reaction tube contained 2 μl cDNA sample, 10 μl SYBR Green QuantiTech Reagent (QIAGEN), 1.25 μl primer pair (Sigma-Aldrich), and RNase free water (Invitrogen) to a final volume of 20 μl. Using LightCycler 1.5 software, data were analyzed and normalized to the expression of -actin. Primers used (Sigma-Aldrich) were as follows: β-actin forward 5′-AGGTGTGATGTGGGAAATGG, reverse 5′-GGTTGGCCTTAGGTCTCAGG; Limk1 forward, 5′-TTATCGGGCGTGGTAATGCA, reverse 5′-ACCAGACAAGTGCATTGGGAA; Creb1 forward 5′-TTGGGAATGCATTTTGGTA, reverse 5′-GGAGGAAAGCAACAGCAA; Dcx forward, 5′-GGAGGTGATGGTGGAATGG, reverse 5′-CAGAGGGG) and 3.5 μM of miRNA universal primer (Applied Biosystems miRNA assay ID 001186) expression was scored based on a new revised Racine Scale (Van Erum et al., 2019): normal behavior (0), generalized behavioral convulsion. The severity of spontaneous seizures was scored based on a new revised Racine Scale (Van Erum et al., 2019): normal behavior (0), generalized tonic-clonic seizure (GTCS), rearing, clonus and loss of balance/posture/falling (5), GTCS + wild running and/or jumping (6) and GTCS ending with full tonic hindlimb extension (180° relative to torso) possibly leading to cardiorespiratory arrest and death (7). Seizure severity assessment was limited to scores (0, 5, 6, and 7) to ensure consistency of analysis. When a mouse was found dead in a cage, the video recording was reviewed to determine whether it was preceded by a severe GTCS ending with full hindlimb extension.

Video EEG recordings of spontaneous seizures and SUDEP during the worsening stage of DS

At P21, another cohort of F1.Scn1α(+/-)tm1kea mice underwent surgery as above to be randomly intra-cerebroventricularly injected with (Ant-134 0.1 nmol in 2 μl PBS) or a nontargeting scrambled control (scr; Exiqon, 0.1 nmol in 2 μl PBS). Three screw electrodes were implanted to allow for EEG recordings and secured with dental cement and surgical glue. The screw electrodes were placed bilaterally to the midline over the cerebral cortex followed by the reference electrode positioned over the nasal sinus. After surgery, animals were immediately placed in an incubator at 33°C and monitored for 30 min. Once fully recovered, single housed mice were connected to the lead socket of a swivel commutator, which was connected to a brain monitor amplifier for EEG digital recordings. Gel diet was added in the cage and vEEG recordings were performed from 12:30 P.M. to 6:30 P.M. (6 h/d) followed by video monitoring from 6:30 P.M. to 12:30 P.M. (18 h/d) until P28. Immediately after acute vEEG recordings, single housed mice in their home cages were transferred to a room equipped with a high resolution, infrared video cameras (Hikvision). Continuous digital videos were recorded at 30 fps and stored in a Dell PC workstation. Video recordings were reviewed offline at 16× speed using VSPlayer software (version 6.0.0.4) and suspected seizures were reviewed at 1× speed. Duration of seizures were defined from the beginning to the end of the behavioral convulsion. The severity of spontaneous seizures was scored based on a new revised Racine Scale (Van Erum et al., 2019): normal behavior (0), generalized tonic-clonic seizure (GTCS), rearing, clonus and loss of balance/posture/falling (5), GTCS + wild running and/or jumping (6) and GTCS ending with full tonic hindlimb extension (180° relative to torso) possibly leading to cardiorespiratory arrest and death (7). Seizure severity assessment was limited to scores (0, 5, 6, and 7) to ensure consistency of analyses. When a mouse was found dead in a cage, the video recording was reviewed to determine whether it was preceded by a severe GTCS ending with full hindlimb extension.

**Statistical analyses**

The normality of the data was analyzed using D’Agostino and Pearson’s omnibus normality test. Data were analyzed using one-way ANOVA, Kruskal-Wallis test (followed by two-stage step-up method of Benjamini, Krieger, and Yekutieli correction for multiple comparisons), unpaired two-tailed Student’s t test, Mann–Whitney U test and Kaplan–Meier method followed by Tukey’s post hoc test, as appropriate. Grubbs’ test with α = 0.01 was applied to detect outliers in mRNA levels of Dcx. The specific statistical test used for each experiment are indicated in the figure legend. Data are expressed as SDs or median with interquartile range (IQR), as appropriate. Differences between groups were considered statistically significant when p < 0.05. Experiments and data were analyzed blind to genotype and treatment. Further information of each statistical test performed are shown in Table 1.

**Results**

**Evaluation of Ant-134 on hyperthermia-induced seizures in F1.Scn1α(+/-)tm1kea mice**

Sensitivity to hyperthermia is a hallmark of DS onset. In the first experiment, we investigated whether the silencing
of miR-134 by Ant-134 could prevent the development of hyperthermia-induced seizures in F1.\textit{Scn1a\textsuperscript{1/C0\textsubscript{tm1kea}}} mice during the febrile stage of DS. A total of six to seven mice per group were used and data were analyzed by Kruskal–Wallis test. At P17, F1.\textit{Scn1a\textsuperscript{1/C0\textsubscript{tm1kea}}} mice were intracerebroventricularly injected with 0.1, 0.5, or 1 nmol dose of Ant-134 followed by the hyperthermia challenge at P18 (Fig. 1A). As body temperature was elevated, all scr F1.\textit{Scn1a\textsuperscript{1/C0\textsubscript{tm1kea}}} mice developed seizures at temperatures ranging from 37.5°C to 39.5°C (\(p = 0.0009\); Fig. 1B) presenting a median duration \(\sim 20\) s (\(p = 0.003\); Fig. 1C) and severity 5 according to a modified Racine scale score (\(p = 0.0006\); Fig. 1D). Notably, none of three different doses of Ant-134 influenced the temperature threshold for seizure development (Fig. 1B). The duration and severity of seizures also remained unchanged in F1.\textit{Scn1a\textsuperscript{1/C0\textsubscript{tm1kea}}} Ant-134-treated mice when compared with F1.\textit{Scn1a\textsuperscript{1/C0\textsubscript{tm1kea}}} scr mice (Fig. 1C,D).
Figure 2. Ant-134 0.1 nmol does not prevent SRS and SUDEP occurrence in F1.Scn1a(+/−)tm1kea mice. A, Schematic showing the experimental design used to investigate the occurrence of SRS, SUDEP and miR-134 levels in F1.Scn1a(+/−)tm1kea mice during the worsening stage of DS. B, Representation of the frequency of SRS experienced by scr and Ant-134 F1. Scn1a(+/−)tm1kea-treated mice according to a color scale ranging from 0 to 10 seizures or more. C, Quantitative analyses of SRS between P21 and P28. D, E, Seizure duration and severity in Ant-134-treated mice compared with scr. F, SUDEP rates between scr and Ant-134 F1.Scn1a(+/−)tm1kea-treated mice. G, Taqman results confirming Ant-134 0.1 nmol produced a knock-down in miR-134 levels when compared with scr mice. H, I, EEG representative trace of SRS in scr and Ant-134 F1.
miR-134, *Creb1, Limk1, Dcx,* and *Scn1a* expression after hyperthermia-induced seizures in *F1.Scn1a (+/−)tm1kea* mice

Next, transcript levels of miR-134 in the ipsilateral cortex and hippocampus were observed between WT controls and *F1.Scn1a (+/−)tm1kea* mice, confirming miR-134 is not differentially expressed in the DS mouse model (Fig. 1E; Extended Data Fig. 1-2). All results reported here were analyzed by one-way ANOVA with a total of six to seven mice per group. No statistical difference in the levels of miR-134 in cortex or hippocampus was observed between WT controls and *F1.Scn1a (+/−)tm1kea* mice treated with 0.1, 0.5, and 1 nmol dose of Ant-134 showed a miR-134 knock-down of 71.7%, 86.9%, and 82.5% respectively, when compared with scr *F1.Scn1a (+/−)tm1kea* mice (p = 0.001, p < 0.0001, and p = 0.0002, respectively; Fig. 1E). Cortical and hippocampal levels of miR-134 targets including *Limk1, Creb1,* and *Dcx* were also investigated (Fig. 1F–H; Extended Data Fig. 1-2B–D). No statistical difference was observed in the levels of all miR-134 targets between WT scr and *F1.Scn1a (+/−)tm1kea* scr mice in both brain regions (Fig. 1F–H; Extended Data Fig. 1-2B–D). In contrast, hippocampal levels of Dcx and cortical *Limk1* levels were upregulated in *F1.Scn1a (+/−)tm1kea* treated mice with ant-134 0.1 nmol when compared with scr *F1.Scn1a (+/−)tm1kea* mice (p < 0.0001 and p = 0.009, Fig. 1H and Extended Data Fig. 1-2B, respectively). These findings confirm that inhibiting miR-134 upregulates some, but not all, miR-134 targets in DS model mice. Lastly, we investigated whether Ant-134 0.1 nmol could have any effect on *Scn1a* transcript levels in DS mice. However, similar *Scn1a* levels were observed between scr *F1.Scn1a (+/−)tm1kea* and Ant-134 *F1.Scn1a (+/−)tm1kea* treated mice in both brain regions (Fig. 1F; Extended Data Fig. 1-2E).

**Ant-134 does not change the frequency of spontaneous seizures and SUDEP in *F1.Scn1a (+/−)tm1kea* mice**

Some therapeutics may fail against hyperthermia-induced seizures but nevertheless work against spontaneous seizures and SUDEP (Hawkins et al., 2017). Previous work showed that Ant-134 when injected at 0.1 nmol reduced seizures evoked by systemic kainic acid in P21 mice (Campbell et al., 2021). Based on this, using a second cohort of mice, we investigated whether Ant-134 dose (0.1 nmol) injected at P21 would reduce the frequency of spontaneous seizures and SUDEP (recorded by vEEG and video monitoring) experienced by F1. *Scn1a (+/−)tm1kea* mice until P28 during the worsening stage of DS (Fig. 2A, n = 6 mice per group).

**Figure 2B,C** shows the frequency of spontaneous seizures and SUDEP for scr and Ant-134-treated F1. *Scn1a (+/−)tm1kea* mice. Student’s t test revealed no difference in the total number of spontaneous seizures over the period between scr and Ant-134-treated F1. *Scn1a (+/−)tm1kea* mice (Fig. 2C). Furthermore, the duration and severity of spontaneous seizures were similar between both groups (Fig. 2D, Student’s t test, E, Mann–Whitney test). Next, we investigated whether Ant-134 had any effect on the incidence of SUDEP in F1. *Scn1a (+/−)tm1kea* mice (Fig. 2F). Notably, no difference was observed in survival rates in F1. *Scn1a (+/−)tm1kea* mice treated with Ant-134 when compared with control (Fig. 2F, log-rank test). Lastly, another cohort of mice were injected at P21 with Ant-134 (0.1 nmol) or its vehicle to assess the silencing of miR-134 in hippocampus at P22 (Fig. 2A,G, n = 6 mice per group). As expected, lower levels of miR-134 were observed in the hippocampus of F1. *Scn1a (+/−)tm1kea* mice treated with Ant-134 when compared with control (Fig. 2G). Ant-134 0.1 nmol promoted a knock-down of ~57% of miR-134 levels in F1. *Scn1a (+/−)tm1kea* mice (Fig. 2G, Mann–Whitney test).

**Discussion**

Extensive preclinical data has shown that inhibition of miR-134 is a potential treatment for drug-resistant focal epilepsy. Recent studies also showed inhibiting miR-134 can reduce evoked seizures in immature mice and reduce seizures in a genetic model of a neurodevelopmental disorder. The present study shows that miR-134 knockdown induced by an ASO anti-miR does not reduce hyperthermia-induced seizures, spontaneous seizures or SUDEP in F1. *Scn1a (+/−)tm1kea* mice. These findings indicate limitations in the application of miR-134 targeting for certain genetic forms of epilepsy.

Early DS symptoms are primarily characterized by febrile seizures emerging during the first year of life (febrile

**Table 1: Statistical table showing the relevant information related to each statistical test performed**

| Experiment | Data structure | Type of test | Power |
|------------|----------------|--------------|-------|
| Fig. 1B–D | Temperature threshold, Seizure duration and Racine scale, respectively | Non-normal distribution | Kruskal–Wallis test |
| Fig. 1F–H and Extended Data Fig. 1-2 | miR-134, *Limk1, Creb1, Dcx,* and *scn1a* relative expression, respectively | Normal distribution | One-way ANOVA |
| Fig. 2C,D | Number of seizure and seizure duration | Normal distribution | Student’s t test |
| Fig. 2E,G | Racine scale and miR-134 | Non-normal distribution | Mann–Whitney test |
| Fig. 2F | % Survival | Non-normal distribution | log-rank test |
The document is a research article discussing the role of miR-134 in epilepsy. The key finding is that Ant-134, a microRNA targeted therapy, did not affect seizure duration, severity or temperature in DS model mice, despite its efficacy in other models. This suggests that the mechanisms driving seizures in DS may differ from other models. The article discusses the implications of these findings for the treatment of epilepsy, particularly in the context of Angelman Syndrome and idiopathic generalized epilepsy (IGE). The references cited include papers on miR-134 and other microRNAs in epilepsy research. The importance of MiR-134 in neuronal function and its potential role in seizure suppression is highlighted.
