Early experiences of nusinersen for the treatment of spinal muscular atrophy: Results from a large survey of patients and caregivers

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Abstract

Background: This study aimed to examine the early experience of nusinersen for spinal muscular atrophy (SMA) from the patient and caregiver perspective.

Methods: A 54-item online survey was administered to adult patients and caregivers of pediatric patients diagnosed with SMA.

Results: Overall, respondents (56 patients and 45 caregivers) were satisfied with nusinersen. Satisfaction was highest on changes in energy, stamina, and motor function and lowest on treatment administration and overall time commitment. Differences were noted for treatment effect sustained over time as reported by adult patients vs caregivers reporting on behalf of pediatric patients. Respondents reported insurance approval as a key barrier to access, particularly among adult patients.

Conclusions: Despite therapeutic advances, there remain significant unmet needs for SMA. Challenges with administration and barriers to access potentially limit the number of patients treated or delay treatment. Continued efforts are needed to develop more treatment options and to improve access to treatments.

KEYWORDS
patient reported outcome, spinal muscular atrophy, unmet need, burden, nusinersen, SMA

1 INTRODUCTION

Spinal muscular atrophy (SMA) is a progressive, genetic, motor neuron disease with an estimated incidence of 9.4 per 100,000 live births in the United States.1 Until recently, the management of SMA was limited to supportive pulmonary, gastrointestinal, nutrition, orthopedic, and rehabilitative care, usually requiring coordination by a multidisciplinary team.2,3 In December 2016, nusinersen, an SMN2 targeting anti-sense oligonucleotide (ASO), became the first disease-modifying therapy approved by the United States Food and Drug Administration (FDA) for pediatric and adult patients with SMA, and was subsequently approved in May 2017 by the European Medicines Agency. Nusinersen is administered intrathecally, with four loading
2.2 | Survey questionnaire

A 54-item survey was developed to assess patient’s early experiences with treatment and their perceptions about current and future SMA treatments. Specifically, the survey assessed demographics, health and treatment history, current medical treatments, assessment of motor function, satisfaction with treatment, barriers to receiving care, and important attributes of a new theoretical SMA medication. The survey was designed to take less than 20 min to complete. Detailed accounts for a few measures are included below. A complete copy of the survey is available as Supporting Information Appendix S1, which is available online.

2.3 | Assessment of motor function

Two questions were included in the survey to assess respondents’ highest motor function ever achieved and the current level of motor function. For ease of reporting, the eight response options were collapsed into three categories: walking alone/walking with assistance/standing alone/standing with assistance were collapsed into standing or greater category; sitting without support/hands and knees crawling were collapsed into sitting; and none of the above: they have some motor function/no motor function were collapsed into minimal function.

2.4 | Experience with current treatment

Patients or caregivers of patients receiving nusinersen were asked to rate their overall satisfaction with nusinersen, as well as satisfaction with specific attributes of this treatment using a five-point scale. For ease of understanding and reporting, the response options of very satisfied/extremely satisfied were referred to as high satisfaction; somewhat satisfied was referred to as medium satisfaction; and a little satisfied/not at all satisfied was referred to as low satisfaction.

Patients or caregivers of patients were asked about the time commitment for treatment, including travel to the administration center and administration and dosing (including time meeting with the medical team, waiting to receive treatment, length of the procedure, and post procedure recovery). Patients were asked to rate the level of comfort or discomfort experienced during administration on a scale of 0–10 (no discomfort - extreme discomfort). Additional questions assessed the amount of time associated with overall care and support for their day-to-day management of their disease.

2.5 | Reasons for not receiving treatment

For patients who had never received or had discontinued nusinersen treatment, the reason(s) for such a decision was asked. Respondents
were provided a list of options regarding possible reasons and could choose multiple responses.

### 2.6 Data analysis

Descriptive analyses (frequencies, mean [SD/median]) were conducted to assess the study objectives. All analyses were conducted for either the entire patient population or in sub-groups specified within the results section. The analysis was conducted in SAS version 9.4 and R version 3.3.

## 3 RESULTS

### 3.1 Patient demographics and clinical characteristics

Within a month, an enrollment goal of 100 patients and caregivers was reached and recruitment was discontinued. Of the 142 survey attempts, 101 patients with SMA were eligible and completed the study, of whom nearly half had type 2 SMA, while most of the remaining patients had type 1 or type 3; only one patient had type 4.

### TABLE 1 Demographic information [Color table can be viewed at wileyonlinelibrary.com]

|                         | All (n = 101) | Adult (n = 56) | Pediatric (n = 45) |
|-------------------------|--------------|----------------|-------------------|
| **Type of SMA**         |              |                |                   |
| Type 1                  | 21 (21%)     | 4 (7%)         | 17 (38%)          |
| Type 2                  | 49 (49%)     | 23 (41%)       | 26 (58%)          |
| Type 3                  | 30 (30%)     | 28 (50%)       | 2 (4%)            |
| Type 4                  | 1 (1%)       | 1 (2%)         | 0 (0%)            |
| **Age (in y)**          |              |                |                   |
| Adult (n = 56)          |              |                |                   |
| Mean                   | 35.38        | 13.20          | 32.50             |
| Pediatric (n = 45)      |              |                |                   |
| Mean                   | 6.58         | 5.37           | 5.00              |
| **Highest motor function** |            |                |                   |
| Walking alone           | 33 (33%)     | 30 (54%)       | 3 (7%)            |
| Walking with assistance | 6 (6%)       | 4 (4%)         | 4 (9%)            |
| Standing alone          | 1 (1%)       | 0 (0%)         | 1 (2%)            |
| Standing with assistance| 8 (8%)       | 4 (7%)         | 4 (9%)            |
| Hands and knee crawling | 9 (9%)       | 4 (7%)         | 5 (11%)           |
| Sitting without support | 29 (29%)     | 14 (25%)       | 15 (33%)          |
| None of the above; I had some motor function | 13 (13%) | 2 (4%) | 11 (24%) |
| No motor function       | 2 (2%)       | 0 (0%)         | 2 (4%)            |
| **Current motor function** |            |                |                   |
| Walking alone           | 8 (8%)       | 7 (13%)        | 1 (2%)            |
| Walking with assistance | 7 (7%)       | 6 (11%)        | 1 (2%)            |
| Standing alone          | 0 (0%)       | 0 (0%)         | 0 (0%)            |
| Standing with assistance| 7 (7%)       | 1 (2%)         | 6 (13%)           |
| Hands and knee crawling | 1 (1%)       | 0 (0%)         | 1 (2%)            |
| Sitting without support | 41 (41%)     | 21 (38%)       | 20 (44%)          |
| None of the above; I had some motor function | 35 (35%) | 21 (38%) | 14 (31%) |
| No motor function       | 2 (2%)       | 0 (0%)         | 2 (4%)            |
| **Insurance coverage**  |              |                |                   |
| Medicare                | 18 (18%)     | 13 (23%)       | 5 (11%)           |
| Medicaid                | 57 (57%)     | 28 (50%)       | 29 (64%)          |
| Private insurance (HMO) | 29 (29%)     | 18 (32%)       | 11 (24%)          |
| Private insurance (PPO) | 38 (38%)     | 17 (30%)       | 21 (47%)          |
| Other*                  | 5 (5%)       | 4 (7%)         | 3 (7%)            |

*aInsurance categories are not mutually exclusive; patient may have multiple insurance coverage.*
4. Forty-one respondents did not meet the study entry criteria. The most common reasons respondents were disqualified was because the respondent with SMA was below the age of 18 y or because the caregiver was either a paid caregiver or was not directly involved in the care and treatment decisions for their patient. The majority of patients were female and privately insured, with an average age of 35.38 y among adults and 6.58 y among pediatric patients. Only 21% of patients were able to maintain a “standing or greater” level of function at the time of the survey, with more than three-quarters of patients currently receiving nusinersen. Full details are provided in Table 1.

3.2 | Patient and caregiver reported experience with nusinersen

Patients and caregivers reported overall high satisfaction with nusinersen. With regard to specific attributes of treatment, adult patients considered changes in “energy and stamina” (58%), “respiratory function” (56%), and “motor function” (47%) to be their top three areas of satisfaction. Caregivers of pediatric patients reported the highest rates of satisfaction with changes in “energy and stamina” (73%), “motor function” (61%), and “social functioning” (61%) (Figure 1).

Adult patients reported the lowest level of satisfaction with the following attributes, “treatment effect sustained over time” (50%), changes in “other symptoms (eg, pain, constipation)” (44%), and “medication administration” (39%). Caregivers of pediatric patients reported lowest satisfaction with changes in “activities of daily living” (37%), “time commitment to treatment” (34%), and “medication administration” (29%). Contrary to adult patients, a higher proportion of caregivers of pediatric patients (54%) reported high satisfaction with treatment effect being sustained over time compared to adult patients (22%) (Figure 1, Table 2).

About half of the respondents reported that they had to drive more than 1 h to a treatment center to receive nusinersen, and about 20% reported a drive time of greater than 2 h. On the day of nusinersen administration, the average time associated with treatment for all patients was more than 8 h, with longer mean administration times reported by caregivers of pediatric patients compared to adult patients (Table 3).

Patients reported a substantial level of discomfort during their treatment administration. With adult patients reporting a higher average discomfort compared to caregivers of pediatric patients.
At the time of survey administration, 24 patients were not receiving nusinersen. The first and second most frequent reason for not receiving treatment included “challenging route of administration” (58%) and “waiting for new treatment options” (46%). Other commonly reported reasons for not receiving nusinersen are listed in Figure 2.

### TABLE 2 Patient satisfaction with nusinersen

| Type 1       | Low satisfaction | Medium satisfaction | High satisfaction |
|--------------|------------------|----------------------|-------------------|
| Adult (n = 3) | 1 33             | 1 33                 | 1 33              |
| Pediatric (n = 16) | 1 6        | 8 50                 | 7 44              |
| Total (n = 19) | 2 11            | 9 47                 | 8 42              |

| Type 2       | Low satisfaction | Medium satisfaction | High satisfaction |
|--------------|------------------|----------------------|-------------------|
| Adult (n = 12) | 8 67             | 2 17                 | 2 17              |
| Pediatric (n = 23) | 5 22         | 4 17                 | 14 61             |
| Total (n = 35) | 13 37            | 6 17                 | 16 46             |

| Type 3       | Low satisfaction | Medium satisfaction | High satisfaction |
|--------------|------------------|----------------------|-------------------|
| Adult (n = 21) | 9 43             | 7 33                 | 5 24              |
| Pediatric (n = 2) | 1 50           | 0 0                  | 1 50              |
| Total (n = 23) | 10 43            | 7 30                 | 6 26              |

*Patients could select multiple responses.

### TABLE 3 Patient and caregiver reported time associated with administration of nusinersen

| Driving time to SMA treatment center | All (n = 77) | Adult (n = 36) | Pediatric (n = 41) |
|-------------------------------------|-------------|---------------|-------------------|
|                                     | n  %        | n  %          | n  %              |
| Less than 1-h                       | 38 49       | 20 56         | 18 44             |
| 1–2 h                               | 25 33       | 11 31         | 14 34             |
| Greater than 2-h                    | 14 18       | 5 14          | 9 22              |
| Mean SD Median                      |             |               |                   |
| Average time driving to treatment center |            |               |                   |
| All (n = 77)                        | 3.52        | 11.31         | 2.00              |
| Adult (n = 36)                      | 1.94        | 1.84          | 1.00              |
| Pediatric (n = 41)*                 | 4.90        | 15.35         | 2.00              |
| Hours spent on activities on the day of administration | | | |
| All (n = 77)                        | 8.26        | 11.29         | 5.00              |
| Adult (n = 36)                      | 4.78        | 2.15          | 4.00              |
| Pediatric (n = 41)*                 | 11.32       | 14.75         | 6.00              |
| Level of discomfort while receiving nusinersen treatment (scale 0–10) | | | |
| All (n = 77)                        | 4.51        | 2.58          | 5.00              |
| Adult (n = 36)                      | 5.14        | 2.44          | 5.00              |
| Pediatric (n = 41)*                 | 3.95        | 2.61          | 4.00              |

*As reported by caregiver respondent.

### 3.3 Reasons for not receiving nusinersen

### 3.4 Experience with insurance approval and coverage

Among patients receiving nusinersen, a large variation in the length of time required for insurance approval was reported. Nearly a third of patients receiving nusinersen reported that their insurance provider approved the use of the treatment in less than 1 mo while nearly half reported an approval time between 1 and 6 mo (Figure 3A). Analyses of
time to insurance approval by SMA type indicated that a higher proportion of type 1 patients received approval in less than 1 mo compared to type 2 and 3 patients (Figure 3A). Time to insurance approval was longer among adult patients compared to pediatric patients (Figure 3B).

| Reason                                      | Type 1, n = 19 | Type 2, n = 35 | Type 3, n = 23 |
|---------------------------------------------|---------------|---------------|---------------|
| Challenging treatment route of administration (intrathecal/spinal tap) |               |               |               |
| Waiting for new treatment options           |               |               |               |
| Side effects                                 | n = 8         | n = 8         | n = 8         |
| Waiting for more clinical data and clinical experience with nusinersen |               |               |               |
| High out-of-pocket cost                      | n = 8         | n = 8         | n = 8         |
| Not convinced of the risk-benefit profile of nusinersen | n = 7        | n = 7        | n = 7        |
| Overall treatment regimen too burdensome    | n = 8         | n = 8         | n = 8         |
| Insurance ineligibility                      | n = 6         | n = 7         | n = 7         |

Of the 77 patients receiving nusinersen, 57 patients had received therapy for longer than 6 mo (“early initiators”), and 20 patients had started treatment within the 6 mo prior to the survey (ie, “late initiators”). Similar delays in approval time were reported by late and early initiators, suggesting insurance approval continues to be a barrier to treatment initiation, despite growing experience with nusinersen over time (Figure 3B).

3.5 Attributes of future SMA treatments

Patients ranked safety (88%, n = 89), efficacy (87%, n = 88), and route of administration (59%, n = 60) as the most important attributes when considering future SMA treatments. While safety and efficacy were consistently ranked as top considerations, adult patients ranked efficacy as the number one factor, while caregivers ranked safety as the most important factor for their younger patients. In addition, ease of insurance approval process (54%, n = 55) and robust clinical data (45%, n = 45) were considered as important attributes when considering future treatments.

4 DISCUSSION

Several clinical trials have demonstrated safety and efficacy of nusinersen as a treatment option for SMA patients, with ongoing clinical trials and real-world studies providing further understanding of long-term functional and subjective impacts of treatment across SMA types.9-18 Recent studies in older patients with SMA have implied real-world benefits with nusinersen treatment in motor milestone achievement, functional assessments, and caregiver burden.9,10,16-18 A real-world safety study concluded that the administration of nusinersen was well tolerated, including in patients that required fluoroscopy guidance, anxiolytics, or general sedation.12 The results of
this study add to the early experiences of treatment with nusinersen from a patient and caregivers perspective. Study results indicated that satisfaction was highest among patients with type 1 SMA. Type 1 patients, due to the severity of the disease and early treatment, may have observed larger treatment benefit compared to patients with type 2 or 3 SMA. Risk tolerance and treatment commitment may also be higher in the more severe type 1 patients due to poor prognosis in the absence of treatment. The sense of optimism and hope in caregivers of type 1 patients, where treatment improves survival and breathing and leads to marked improvement in strength and function, may have played a role in the high level of treatment satisfaction observed in the survey.

As such, not surprisingly, caregivers of pediatric patients indicated high satisfaction with enhanced energy, motor function, and improvements in social functioning. However, they reported low satisfaction with improvements in activities of daily living. The desire for further gains in patients’ functional ability was consistent with an earlier report that small changes that provide greater independence in activities of daily living are of vital importance to children and adolescents. Adult patients indicated a high level of satisfaction with treatment-related improvements in energy levels, respiratory functioning, and motor function; however, they were less satisfied with the treatment effect over time. Although initial pharmacokinetic and pharmacodynamics studies support the approved dosing regimen for nusinersen, it is possible that higher doses may provide improved or sustained responses.

Both caregivers and patients expressed concerns about medication administration. Intrathecal administration can be particularly challenging for patients with SMA. For patients with type 1 SMA, life-threatening respiratory symptoms, often requiring the presence of a multi-disciplinary care team at the time of treatment administration, frequent sedation, and radiation exposure could cause concern. Spinal complications may limit the ability for a patient to receive nusinersen, although recent research has indicated that individuals with complicated spines can receive nusinersen injections using fluoroscopic guidance. In our study, however, the route of administration was noted as the primary reason for not being able to receive nusinersen treatment among both adult and pediatric patients.

Similar findings were reported by Pechman and colleagues who reported that, while intrathecal administration of nusinersen could be performed in all children with type 1 SMA, lumbar punctures were unsuccessful in 33% of children on the first attempt. In addition, 35% required non-invasive mechanical ventilation, and 24% required sedation during the lumbar procedure. Furthermore, Mousa and colleagues reported that, given the frequency of spinal deformities among patients with SMA, the intended treatment protocol for nusinersen had to be adapted for a number of patients to include pre-procedural imaging.

Results of this study also indicated that patient satisfaction with nusinersen treatment was higher than physician satisfaction with treatment. In a survey of 51 physicians treating patients with SMA, lower satisfaction was reported by treating physicians, with 20% of physicians reporting overall high satisfaction with nusinersen compared to 56% of adult patients and 66% caregivers reporting overall high satisfaction with nusinersen. This observation could be accounted for by many factors that may include physicians reporting on behalf of the overall patient population (ie, including both pediatric and adult patients), high level of requirement for setting treatment infrastructure of administration, high level of effort involved to secure insurance approval and recertification, and lack of clinical data in a real-world patient population, limiting physicians’ ability to make treatment recommendations for patients not in nusinersen clinical trials.

The current study also identified several barriers associated with SMA treatment, with insurance approval and amount of time associated with traveling to receive treatment reported as key barriers to access to treatment. The key reasons reported by patients in this study for not receiving nusinersen treatment were similar to those reported by Pacione et al. They noted that key factors influencing patient’s treatment decisions were concerns about risk factors and side effects, high cost, insurance coverage, time involvement, and lack of efficacy data.

It is important to note the barriers to access and attributes of treatment that are challenging for patients as these might potentially delay or limit treatment for some patients diagnosed with SMA. As the SMA treatment landscape evolves, it is critical to address these unmet needs, as early diagnosis and treatment of SMA are necessary to maximize effectiveness of the treatment and improve health outcomes in patients. Indeed, when patients were asked about the most important attributes of a future treatment, improved route of administration was indicated as one of the most important aspects of treatment, following efficacy and safety.

4.1 Limitations

It is important to interpret these results in light of the study’s limitations. For example, patients who responded to this survey were recruited from a database of a patient organization and may not be representative of all individuals diagnosed with SMA. This is evident in that three out of four patients in the survey were, or had been, treated with nusinersen, whereas among all patients with SMA, approximately 20%-30% were receiving treatment during the same period. In addition, clinical information, such as SMA type and highest and current motor function, was reported by the patients or their caregivers; no verification against clinical documentation was attempted.

Further research is needed to explore the needs and perspectives of patients who are not affiliated with the patient community or less active in research participation, in order to have a more complete picture of ongoing unmet need and challenges in the SMA community. Additionally, it is important to interpret these results with caution as they reflect early experiences of a new disease modifying treatment. For example, in this study, 20 patients had received treatment for less than 6 mo prior to the survey, limiting their exposure to the drug and likely treatment benefit. Furthermore, treatment effects reported are based on self-report and not clinically verified. Furthermore, the current survey was conducted prior to the approval of onasemnogene abeparvovec xioi and, thus, does not describe patients’ experiences
with this new treatment; consequently, the results are reflective of only one available treatment. Last, there is likely a difference between self-reported satisfaction from patients vs satisfaction from caregivers of pediatric patients. Treatment benefit is based on observation from the caregiver and the responses of the pediatric caregiver may not be fully representative of the pediatric patients.

4.2 Conclusions

Despite the availability of treatment options, there remain unmet needs and several barriers to access, potentially delaying or limiting treatment for some SMA patients. Efficacy, safety, and route of administration have been identified by patients as key attributes for future medications to treat SMA. As the SMA treatment landscape evolves, continued efforts are needed to improve timely access to treatments for patients and reduce barriers to care.

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CONFLICT OF INTEREST

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AUTHOR CONTRIBUTIONS

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REFERENCES

1. Lally C, Jones C, Farwell W, Reyna SP, Cook SF, Flanders WD. Indirect estimation of the prevalence of spinal muscular atrophy type I, II, and III in the United States. Orphanet J Rare Dis. 2017;12(1):175.
2. Finkel RS, Mercuri E, Meyer OH, et al. Diagnosis and management of spinal muscular atrophy: part 2: pulmonary and acute care; medica-
tions, supplements and immunizations; other organ systems; and ethics. Neuromuscul Disord. 2018;28(3):197-207.
3. Mercuri E, Finkel RS, Muntoni F, et al. Diagnosis and management of spinal muscular atrophy: part 1: recommendations for diagnosis, rehabil-
itation, orthopedic and nutritional care. Neuromuscul Disord. 2018;28(2):103-115.
4. Food and Drug Administration. FDA approves first drug for spinal muscular atrophy. 2016. https://www.fda.gov/newsevents/ newsroom/pressannouncements/ucm534611.htm. Accessed June 20, 2019.
5. Cure SMA. AveXis files for FDA approval of gene therapy for spinal muscular atrophy type I. 2018. http://www.curemsa.org/news/ avexis-fda-approval-type-i.html Accessed June 20, 2019.
6. Novartis. AveXis receives FDA approval for Zolgensma®, the first and only gene therapy for pediatric patients with spinal muscular atrophy(SMA). 2019. https://www.novartis.com/news/media-releases/avexis-receives-fda-approval-zolgensma-first-and-only-gene-therapy-pediatric-patients-spinal-muscular-atrophy-sma. Accessed June 25, 2019.
7. Cure SMA. The Voice of the Patient Report for Spinal Muscular Atro-
phy 2018.
8. Noone JM, Whitmire SM, Buchengerger D, Mills R, Guittari CJ, Chen E. Clinical Experience of Spinal Muscular Atrophy (SMA) Treatment: A Combination of Perspectives from a Large Survey. Poster Presented at Cure SMA 23rd International SMA Research Meeting. Anaheim, CA; Dis-
neyland; 2019.
9. Quinn C, Fadda G, Michon S, et al. Effect of nusinersen in an adult SMA cohort: CSF biomarkers and RULM. 2020 American Academy of Neurology Abstract Website. 2020 https://index.mirasmart.com/AAN2020/PDFFiles/AAN2020-004725.html. Accessed June 11, 2020.
10. Johnson N, Paradis A, Naoshy S, Wong J, Montes J, Krasinsky D. Evaluation of nusinersen on impact of caregiver experience and HRQOL in later-onset spinal muscular atrophy (SMA): results from the phase 3 CHERISH trial. 2020 American Academy of Neurology Abstract Website. 2020 https://index.mirasmart.com/AAN2020/PDFFiles/AAN2020-001429.html. Accessed June 11, 2020.
11. Day J, Swoboda K, Darras B, et al. Longer-term experience with nusinersen in teenagers and young adults with spinal muscular atro-
phy: results from the CS2/CS12 and SHINE studies. 2020 American Academy of Neurology Abstract Website. 2020 https://index. mirasmart.com/AAN2020/PDFFiles/AAN2020-001132.html. Accessed June 11, 2020.
12. Goedeker N, Gibbons J, Zaidman C. Real-world experience of nusinersen safety. MDA Clinical & Scientific Conference 2020. https://mdaconference.org/node/1027. Accessed June 11, 2020.
13. Bermudez C, Frank S, Kolb S, et al. Quality of life in adults with spinal muscular atrophy. 2020 American Academy of Neurology Abstract Website. 2020 https://index.mirasmart.com/AAN2020/PDFFiles/AAN2020-002716.html. Accessed June 11, 2020.
14. Oskouli M, Vajsar J, Hodgkinson V, et al. The Canadian neuromuscular disease registry: a national spinal muscular atrophy (SMA) registry for real world evidence. 2020 American Academy of Neurology Abstract Website. 2020 https://index.mirasmart.com/AAN2020/PDFFiles/AAN2020-002403.html. Accessed June 11, 2020.
15. Chiriboga C, Darras B, Farrar M, Mercuri E, Kirschners J, Kuntz N. Lon-
ger-term treatment with nusinersen: results in later-onset spinal...
muscular atrophy from the SHINE study. 2020 American Academy of Neurology Abstract Website. 2020 https://index.mirasmart.com/AAN2020/PDFfiles/AAN2020-001661.html. Accessed June 11, 2020.

16. Veerapandiyan A, Eichinger K, Guntrum D, et al. Nusinersen for older patients with spinal muscular atrophy: a real-world clinical setting experience. Muscle Nerve. 2020;61(2):222-226.

17. Hagenacker T, Wurster CD, Günther R, et al. Nusinersen in adults with 5q spinal muscular atrophy: a non-interventional, multicentre, observational cohort study. Lancet Neurol. 2020;19(4):317-325.

18. Daimee M, Shakti N. Nusinersen initiation in adults with spinal muscular atrophy. 2020 American Academy of Neurology Abstract Website. 2020 https://index.mirasmart.com/AAN2020/PDFfiles/AAN2020-004906.html. Accessed June 11, 2020.

19. Finkel RS, Chiriboga CA, Vajsar J, et al. Treatment of infantile-onset spinal muscular atrophy with nusinersen: a phase 2, open-label, dose-escalation study. Lancet. 2016;388(10063):3017-3026.

20. Cartwright MS, Ward ZT, White EP, West TG. Intrathecal delivery of nusinersen in individuals with complicated spines. Muscle Nerve. 2020;62(1):114-118. https://doi.org/10.1002/mus.26899.

21. Peichmann A, Langer T, Wider S, Kirschner J. Single-center experience with intrathecal administration of Nusinersen in children with spinal muscular atrophy type 1. Eur J Paediatr Neurol. 2018;22(1):122-127.

22. Mousa MA, Aria DJ, Schaefer CM, et al. A comprehensive institutional overview of intrathecal nusinersen injections for spinal muscular atrophy. Pediatr Radiol. 2018;48(12):1797-1805.

23. Pacione M, Siskind CE, Day JW, Tabor HK. Perspectives on Spinraza (Nusinersen) treatment study: views of individuals and parents of children diagnosed with spinal muscular atrophy. J Neuromuscul Dis. 2019;6(1):119-131.

24. Cure SMA. SMA Treatment Access and Clinical Trials Webinar. 2018.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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